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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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Whitehall Place, S.W.
F 767

Patents and Designs Act, 1907.

Notice is Hereby Given that

GEORGE RICHARDS, of *No. 5*, Grocers' Hall Court, Poultry, London, Engineer; and HENRI DESPAIGNE, of 146, rue Brockmans, Brussels, temporarily residing at 439, Oxford Street, London, Engineer, seek leave to amend the specification of Letters Patent No. 14371 of 1915 granted to them for "Improvements in the Methods of Milling Screw Threads."

Particulars of the proposed amendment were set forth in the *Illustrated Official Journal (Patents)*, issued on the 6th December, 1916.

Any person, or persons, may give notice of Opposition to the Amendment by leaving Patents Form No. 18, at the Patent Office, 25, Southampton Buildings, London, W.C., within one calendar month from the date of the said Journal.

W. TEMPLE FRANKS,
Comptroller-General. F 757

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The following information must accompany each offer, which must be addressed to Mr. HUBERT BAINES, Deputy Chief Engineer, H.M. Office of Works, King Charles Street, Whitehall, London, S.W.:—Type, size and weight; maker's name; when built; when and by whom last overhauled; condition; price.

H.M. Office of Works, &c.,
28th November, 1916. F 697

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The MINISTRY OF MUNITIONS are prepared to receive

Offers of Good Second-

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H.M. Office of Works, &c.,
11th December, 1916. F 714

CORPORATION OF CALCUTTA.

NOTICE TO CONTRACTORS.

Tenders are Invited, in

duplicate, for STORM WATER PUMPING PLANT, and will be received by the Deputy Chairman of the Corporation up to Two p.m., on Friday, the 1st June, 1917, when they will be opened in the presence of such tenderers as may be present. Each Tender, in duplicate, must be enclosed in a sealed cover and superscribed, "Tender for Storm Water Pumping Plant." Further particulars may be had by applying to the Chief Engineer, Municipal Office, Calcutta. Specifications, with site drawings, contract agreement, Tender form and rules with regard to Tenders, may be obtained from the office of the *Indian and Eastern Engineer*, 50, Fenchurch Street, London, England (or at Calcutta, from the Secretary to the Corporation), on payment of Ten Shillings for each combined copy. Tenderers must abide by the Corporation rules in regard to Tenders. Tenders must hold good for at least two months from the date of opening of the same.

C. C. CHATTERJEE,
Secretary to the Corporation.
Central Municipal Office,
23rd October, 1916. F 554

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The above Corporation are replacing a set of STEAM DRIVEN DEEP WELL PUMPS, which are being removed to install larger plant.

The Pumps are in thorough working order and are capable of delivering approximately, 8000 gallons per hour.

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Further particulars and order to view may be had from the Engineer.

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The Corporation do not bind themselves to accept the highest or any offer.

W. J. RENDELL BAKER,
Offices— Engineer and Manager.
Northgate Street,
Devizes. F 709

APPOINTMENTS OPEN.

TO MECHANICAL ENGINEERS.

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Applicants must be over military age or otherwise exempt from military service.

Letters should be addressed—
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The Senate invite

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ALFRED PEARCE GOULD, F 705
Vice-Chancellor.

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works office, small tool and general work. Birmingham district. No person already employed on Government work will be engaged.—Apply, nearest LABOUR EXCHANGE, mentioning this Journal and F 718.

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THE NAVAL WAR AND THE SIZE OF BATTLESHIPS.

By WILLIAM HOVGAARD, Brookline, Mass., U.S.A.

(*Continued from page 593.*)

THE foregoing discussion, based as it is exclusively on published reports, is of course subject to certain errors due to the incompleteness and inaccuracy of the available information, but it is believed that such errors will not invalidate the general conclusions.

PRINCIPAL CLAIMS GOVERNING THE DESIGN OF BATTLESHIPS.

Seagoing Capability.—The principal field of operation of battleships is on the high seas. These vessels must therefore be so designed that they can keep the sea for extended periods without undue strain on the *personnel* and *matériel*. They should afford a dry and steady platform for the guns under all conditions of the sea, and should possess sufficient structural strength to stand the strains when steaming at full power in a seaway. These fundamental claims profoundly influence the choice of the principal dimensions, the freeboard, the form of the hull, the structural arrangements, and the distribution of weights.

Speed and Armament.—The battles of the Dogger Bank, Falkland Islands and Jutland, as well as several minor actions (Sydney *v.* Emden) in the present war, have demonstrated the enormous value of combined superiority in speed and gun-power. In fact, a ship possessing the speed-gauge and armed with guns of greater effective range can annihilate a weaker enemy with relatively small risk to itself under all conditions that permit fighting at extreme ranges. This twofold superiority, for which we venture to propose the name of the "speed-armament gauge," must be a fundamental principle in future battleship design. A commander whose vessel possesses this advantage will be in perfect control of the situation. He can accept or refuse battle at will, and when fighting he can choose and control his own range. Provided the skill of his gunners is equal or superior to that of the enemy, he may fight at extreme ranges and choose the conditions of wind, sea and light most favourable to himself and most unfavourable to the enemy, who with his short-range guns will be overwhelmed without being able to return the fire effectively. The loss of the Blücher is a case in point.

The principle of the speed-armament gauge must indeed govern the design of all classes of vessels armed with artillery as their principal weapon. It is based on a purely technical superiority, which can be fully attained only by the most wealthy of the belligerent nations; but all who wish to secure control of the ocean in time of war must strive to approach as near as possible to the ideal embodied in this principle. High speed in battleships is necessary now more than formerly, also on account of the danger of attack from submarines.

In deciding upon the quantitative values of speed and armament the simple rule, following from the aforesaid principle, is that the speed as well as the power and effective range of the guns should be superior or at least equal to those of the battleships of possible and probable enemies. In the British Navy this rule has always been followed consistently as far as the artillery is concerned, but the speed has not always been increased as required so as to secure the speed-armament gauge. For instance, the step from the 12-in. gun in the early dreadnoughts to the 13½-in. gun in the Orion class was not accompanied by a corresponding increase in speed, which remained at 21 knots. In the Queen Elizabeths, on the other hand, the adoption of the 15-in. gun was coupled with a rise in legend speed to 25 knots, but this excellent and logical design was again departed from in the Royal Sovereigns, which are designed for a legend speed of 21 or 22 knots only.

It is likely that the power and range of guns as well as the speed of battleships will increase in the near future, but it is futile to attempt to give numerical figures under the present rapidly changing conditions. It is sufficient to recognise the principle of the speed-armament gauge. Every naval Power must determine for itself how far it is capable of following it.

Ships of the battle-cruiser type must have a speed of not less than 20 per cent. higher than that of ordinary battleships, while the range and power of the guns should be at least as great as in battleships. The number of guns, on the other hand, may be reduced.

Radius of Action.—Battleships of the larger navies may be required to operate in distant seas under circumstances where a supply of fuel may not always be assured. The full bunker capacity should therefore be very considerable.

Protection.—Battleships must possess a reasonable security against attack by artillery on ordinary fighting ranges. Absolute security cannot be obtained, and opinions may differ as to the degree of protection which may be considered satisfactory. We shall here merely state that the power of resistance of the armour should be in a sense proportioned to the penetrative power of the heavy guns ordinarily carried by battleships and of the probable fighting ranges. While the thickness of vertical armour as fitted in modern battleships appears to be adequate at present, it would seem that greater weight and attention should be devoted to horizontal armour on account of the increased angles of fall of projectiles under modern long-range fighting and on account of the possibility of attack from aircraft. The increased danger of submarine attack and damage has enhanced the claims to under-water protection, and these claims can only be met by an additional expenditure of weight, whether in the form of a more minute watertight subdivision, in the form of external or internal armour, or special features of construction and appliances.

Battle-cruisers may be designed to fight primarily at extreme ranges, a condition with which they can generally comply in virtue of their superior speed, at least when weather conditions permit. The armour can therefore be made somewhat lighter than in battleships, but if the reduction is carried too far they are unfit for fighting battleships at close ranges.

A more ideal solution is obtained by giving battle-cruisers practically the same protection as battleships, in which case they can be employed in fleet actions at all ranges. The idea of the battle-cruiser was, to the author's knowledge, first advanced in a paper by the author entitled "The Cruiser," read before the Society of Naval Architects and Marine Engineers in New York, in 1905, when a vessel of this ideal type was proposed. A study of the problem of the armoured cruiser in its fundamental aspects led to the conclusion that the then existing types (Minotaur, Tennessee) were unsatisfactory and no resting point could be found in intermediate types, because they would at some time or other be placed at a disadvantage when fighting battleships. The author therefore recommended a "battleship-cruiser," as he then called it, which was simply a battleship of extra high speed and with a reduction in the number but not in the calibre of guns. The first battle-cruisers, the Invincibles, 1907, fell far short of this ideal, having only 7-in. armour on the belt, and although the thickness was gradually increased in the following types, it remained considerably lighter than in the battleships. The Queen Elizabeths, at the time of their design, were the first representatives of the type of battle-cruiser here recommended, although officially classed as battleships. The only serious objection to this solution is that the displacement is apt to be excessive, whence every effort must be made to save weight, as by the use of oil fuel and refinements in the construction and design of hull and machinery.

Under-water protection in battle-cruisers must be obtained by the same means as in battleships, but on account of the smaller beam and greater length of this type of vessel they should be made to rely to a greater extent on transverse subdivision.

TECHNICAL QUALITIES AND SIZE.

In comparing large and small ships we assume that they are essentially similar in form of hull, differing only in the principal dimensions, and that the principal weight groups of the design form the same percentage of the displacement. This simplifies the discussion and corresponds fairly with the actual conditions so long as the general character of the design remains unaltered.

Nautical Qualities.—Conditions on the ocean are the same for all ships, large or small. The state of the sea, which so largely influences the behaviour of a ship and therewith the service and the life of the crew, enters, so to speak, as a constant factor in the design. If a ship is to be serviceable as a gun-platform and if it is to afford a convenient and healthy station for the crew, it must possess certain nautical qualities, the most important of which are the following:—

Steadiness.—Required for good gun-practice and for comfort of the crew.

Stiffness.—Required for safety in case of under-water damage, and in particular for preventing too great inclinations of the ship when side compartments are flooded.

Dryness, allowing the guns to be used in a seaway unhindered by spray and being generally desirable for an efficient performance of the service of the ship and the comfort of the crew.

Manœuvring Power and Handiness.—Required in tactical manœuvres, when going in or out of port, and under many other circumstances.

Structural Strength.—Required to withstand the stresses to which the hull is subject in a seaway.

The claims to steadiness and stiffness are conflicting, since a stiff ship is naturally not a steady one, having a short period of oscillation on account of its great metacentric height, but the larger a ship is the more completely can both claims be satisfied. The reason of this is that in similar ships both the period of oscillation and the metacentric height increase with size, the former being proportional to the square root of, the latter being directly proportional to the linear dimensions. Rolling and pitching movements are less violent in larger ships than in smaller under the same conditions of the sea, because the effective wave slope is smaller for the larger ships.

Larger vessels are naturally more dry than smaller because they have higher freeboard. The guns, moreover, are mounted at a greater height above the water.

Manœuvring power and handiness, on the other hand, are obviously inferior in larger vessels.

As regards strength and weight of hull an increase in size beyond a certain limit is unprofitable. If the stresses are to remain the same, the weight of the strength hull should, according to the standard theory, increase with size about as the four-third power of the displacement, but certain moderating circumstances tend to reduce this rate to some extent. So far the increase in hull weight due to this cause has been obscured for several reasons, notably by the introduction of stronger materials of construction, to which must be added that in battleships the structural strength of the hull is augmented by the presence of protective decks and by the heavy plate structure behind armour in such a way as to further conceal the virtual increase in weight of the strength hull. The influence of size in this respect is more clearly exhibited in merchant vessels, which occur contemporaneously in greatly varying sizes and reach much larger displacements than warships. In the French liner La France, for instance, of 28,000 tons displacement, the weight of the strength hull is, according to Bertin, about 40 per cent. of the displacement, but in the Imperator, of 57,000 tons displacement, it is about 50 per cent.

Summing up, it is seen that larger ships are intrinsically superior to smaller in point of steadiness, stiffness, dryness and general behaviour in a seaway, and these qualities cannot be obtained in the same measure in smaller ships, however great their number.

The smaller manœuvring power of larger ships may be in some measure remedied by increasing the rudder area and by providing a relatively more powerful steering engine. In fact, for ordinary tactical purposes this drawback, inherent in larger size, can probably in this way be disposed of. It deserves to be noted in this connection that in view of the dangers of submarine attack, battleships, whether large or small, ought to be capable of quick manœuvring on a small space even when the ship is going at slow speed or lying still. This could be

attained by providing the ships with special means for turning in addition to the ordinary stern rudder.

The relative increase in hull weight of larger ships will entail a reduction in the factors on which depend the military qualities. Unless, therefore, this difficulty can be obviated by the use of stronger materials of construction, it must ultimately act as a deterrent to further increase in displacement.

Speed.—The most appropriate speed of a larger vessel is higher than the corresponding speed of a smaller vessel. Roughly, it may be reckoned that if the displacement is increased a certain moderate percentage, we may obtain equally favourable conditions of driving if the speed is augmented by about one-sixth of this percentage. The increase in speed obtained under this rule is indeed moderate. For instance, an increase of the displacement from 24,000 tons to 30,000 tons, or 25 per cent., would allow an increase in speed of only about 4 per cent. If the speed of the smaller ship was 20 knots, the "corresponding" speed of the larger would be 20¾ knots.

Another and very important advantage inherent in the larger ship is that it is better capable of maintaining its speed in a seaway. In other words, the sea speed bears a greater proportion to the smooth-water speed in larger than in smaller vessels.

Endurance.—Since the weight of fuel is by supposition the same percentage of the displacement in large and small ships, and since propulsion at a given cruising speed is relatively more economical in the former, larger ships will be able to travel a greater distance without replenishing their supply of fuel. Or we may say that larger ships are able to cover the same distance at a somewhat higher speed than smaller.

The endurance of larger vessels is superior also in point of provisions and stores on account of the comparatively smaller crew and reduced consumption of stores.

Armament.—It has been shown above that a larger ship is intrinsically more suitable as a gun platform than a smaller. Since, moreover, the weight available for the armament varies as the displacement, and the moment of stability varies as the fourth power of the linear dimensions in similar ships, larger ships are able to carry a battery of heavier guns at a greater height above the water-line without prejudicing the stability. Or, if the weight of individual guns remains the same, a more numerous battery may be carried at a higher level.

Protection.—The weight that can be devoted to protection varies as the displacement—that is, as the third power of the linear dimensions; while the area to be covered with armour varies only as the second power. Larger ships can therefore carry an armour of greater thickness or of more extended area than smaller. The designers may take advantage of this fact, for instance, by improving upon the under-water protection.

In a large vessel the height between decks and the size of cellular spaces need be no greater than in a small vessel, so that the former can without inconvenience be more minutely subdivided than the latter, and thus rendered more secure against all kinds of submarine dangers.

Cost and Economy.

Comparing a fleet consisting of a certain number of large battleships with a more numerous fleet of small battleships of the same aggregate tonnage, it appears that the first cost of the former must be less than that of the latter, since in the construction of larger vessels the overhead expenses and the cost of labour can be reduced. Also the running expenses will be smaller for the large vessels, because the total consumption of fuel, provisions and stores and the cost of docking will be less. Finally there will be a saving on account of the reduction in the total complement of the fleet.

(To be continued.)

Greenland Graphite.—Whilst copper extraction in Greenland has been left in abeyance, not for want of ore, but on account of the high freights and high prices for fuel, the graphite production is increasing and the work being extended. The deposits are large and the percentage of graphite greater than in most other deposits outside Ceylon. American machinery has been installed and the manufacture of crucibles will be taken up in earnest.

THE INSTITUTION OF MECHANICAL ENGINEERS.

An ordinary general meeting of the above Institution was held on Friday last, the 15th inst., at the Institution of Civil Engineers, Great George-street, Westminster, the chair being taken, in the absence of the president through indisposition, by Mr. Michael Longridge, vice-president.

The secretary announced that since the last meeting 83 candidates had been elected to the several grades of membership, while three transferences had been made from the class of associate member to that of full member.

Variable Speed Gears for Motor Road Vehicles.

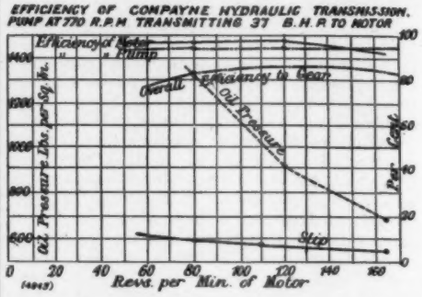
The paper down for reading and discussion was one bearing the above title, by Mr. Robert E. Phillips, of London. This paper, of which we commence the publication in our present issue (page 625) was read in abstract by Mr. Phillips.

The chairman, in declaring the discussion open, remarked that the paper was one of a class to which the Institution was rather more accustomed in bygone years; it was descriptive, it aired no theories and gave no experimental results. It was to be desired, in relation to such papers, that greater space were available in the "Proceedings" for the introduction of dimensioned drawings, these being among the most valuable features of such papers as that by Mr. Phillips.

Dr. H. S. Hele-Shaw opened the discussion, remarking that the author, while inviting the upholders of different systems to enter upon discussion, had wisely avoided a comparison of merits. Indeed, a more useful thing than any discussion of these relative merits would be additional information. He believed that the law of "survival of the fittest" was applicable more to the engineering than any other art, and from this standpoint he considered the step by step method of speed variation satisfied requirements more completely than any system of continuous variation. Many difficulties had been surmounted, and the engineer of twenty years ago would have been appalled to think of the horse-power transmitted by the ridiculously small wheels in use. As a secondary result of research many valuable lessons had been learnt in relation to the properties of the nickel, chrome, and other steels required. The author had remarked that the step by step system had held the field by reason of its flexibility; he might have added "by the power of the petrol motors." The speaker instanced the Ford car, stating that he had rarely seen the drivers of these cars change the gear except when checked. When it came, however, to a question of transporting heavy loads over places where there were no roads suitable for wheels, it would be seen whether or not the continuous variable gear would have its day. Enough was known to make it certain that loads of 20 to 30 tons would be so transported in the future. Large sums of money had been expended on the development of the continuous variation type, apparently unprofitably, but it had been applied for a large number of purposes in engineering for which it was impossible to use the high-speed dynamo or petrol motor, thus affording collateral advantages. The two types of hydraulic transmission mentioned by the author, namely, the Hall and Compayne, the speaker regarded as in line with the Thomas or the Stevens. The Hall transmission, described in the appendix to the paper, was a beautiful type. The author had stated that with the motor cylinders working at their lowest capacity the highest speed was obtained, the casing then rotating at the same speed as the driving shaft. Dr. Hele-Shaw exhibited on the wall a drawing of a 5-ton lorry, directing attention, among other things, to the chain drive, a beautiful arrangement where variation was desired. The Hall design had not come into general use because of the difficulty in obtaining a suitable pump and motor. The design also embraced direct drive on the top speed. There was no waste or loss through hydraulic connection.

Dr. Hele-Shaw then considered the annexed diagram of efficiency for the Compayne gear, particulars of which will appear, in our next issue, in the last part of Mr. Phillips' paper. Among other things Dr. Hele-Shaw pointed out the three efficiencies, the motor, approximating to 100 per cent., that of the pump (separately tested), and the overall efficiency, with slip or leakage subtracted. One of the pumps had been running on a cruiser, making 1,000 revolutions per minute, practically continuously; no packing was used, and there was no trace of wear on the hardened surfaces.

Dr. Hele-Shaw contended that as the human element must enter into the operation of the so-called automatic change-speed gear, it should rather be described as semi-automatic than as automatic. In the Linley system, for instance, the mere fact that a clutch or lever had to be put into another notch rendered it semi-automatic, although the wheels would then come into their proper place



without danger of clash. The speaker also referred to an invention which he described as a kind of automatic gear in which no wheels were necessary. The principle was that of the stored energy in a flywheel, or of a bob weight, which at each revolution moved to and fro, imparting an impulse to the driving wheels. The contrivance he referred to was therefore such as to give the energy of acceleration and retardation. He was, unfortunately, not at liberty to go into details, but more would be heard of this invention.

The author had referred to the plurality of pulley and belt transmissions, allocating the former to the German school and the latter to the French. The speaker, however, contended that it was the French school which had brought the train of wheels to its present perfection, which was really representative. In conclusion, Dr. Hele-Shaw urged that whatever reproach attached to this country in the matter of mechanical progress, our transport service must be an exception. Notwithstanding the stream of motors in use for the advance on the Somme there were no breakdowns, while the French owed their success at Verdun to a similar cause. Our French Allies had reaped the reward of their pioneer work, by making a success of road locomotion through the medium of the gear-box.

Mr. A. Batten was the next speaker. He stated that last year he was in New York, when he saw going along Broadway a picturesque development of the Owen magnetic car. While he could not claim that he had thoroughly examined the car, he had looked it well over and had had a run on it. This particular car had no gear-box or gear lever; it had, however, a mechanical brake, scarcely ever used. There was no clutch. All familiar with motor cars would know that the parts which wore out most quickly were the gear-box and the clutches. A 30-h.p. six-cylinder engine, giving 50 h.p. at 1,500 r.p.m., was fitted to this car. As far as could be gathered from Mr. Batten's necessarily condensed description, the electrical equipment on this car was (as was pointed out by Mr. Phillips in his reply to the discussion) practically identical with that of the Germain electric system described in the latter part of Mr. Phillips' paper. He then narrated what was done with the car on a hill in Central Park. As the car was running along the driver had his foot on the accelerator; he gradually took it off, and the car gradually stopped. On removing his foot entirely the car ran down the track backwards. He again put his foot on the accelerator, and it started up the hill. In this way the car executed a see-saw up and down the hill. The driver had then shown Mr. Batten how he could skid the wheels—a matter for surprise to the speaker, as he had been told that the action

between the engine and the road wheels was absolutely elastic, that the wear on the tyres was very, very small, and that rushes, jerks and bumpings were obviated. A thing that had impressed the speaker very much in regard to comfort of driving was that there was no need to pay any attention to braking; it was simply necessary to take the foot off the accelerator; and when the car drove the generator faster than the engine there was a reverse current in the motor, resulting in a magnetic brake between the revolving armature of the motor and the stationary field magnets. The mechanical brakes were therefore never really used save in emergencies.

Mr. T. Clarkson remarked that the subject of variable speed gears was one which has a special fascination for mechanical engineers, and had come into great prominence owing to the remarkable development of mechanical road vehicles. A great deal of time and energy had been lost owing to slavish adhesion to the old tradition of the steam locomotive, which, of course, had no variable gear. Conditions, however, were essentially different. On a railway there was always a hard surface to run on; on a roadway the surface was sometimes very soft. Moreover, the curves on the road were difficult in comparison with those on a railway. He had taken a pride in stating that a steam omnibus could be run without a gear-box, and as a matter of fact they were so run successfully. Yet it had to be recognised that no engine could overcome obstacles, and develop its full power, without a chance of getting a reasonable piston speed. If, therefore, the principle of the change gear-box were accepted—even for the steam engine, the most flexible type—there was straightway the advantage of a much lighter and simpler engine, and the advantage also of a free engine. That was a very important condition when account was taken of the fact that a commercial car had frequently to wait for fairly long periods, when under ordinary conditions the engine becomes cool and more or less water-logged. The success of the gear-box was, of course, entirely bound up with the efficiency of the friction clutch, a fact that had not been brought out in the paper. The clutch had been brought to a very high degree of efficiency, and the speaker considered that to-day it would be accepted as a very matured type of mechanism. So far as the speaker was aware the most satisfactory and efficient form of clutch was the single plate clutch, with the "Ferodo" or similar asbestos frictional material, and by the employment of such a clutch, in combination with the gear-box, the most efficient speeds for the engine, to enable it to develop its full power, could be obtained. The question of engaging gears—which was, of course, where most of the wear occurred—rendered it necessary to have a very hard material, capable of withstanding rough treatment. The wear, of course, developed noise, and for London omnibuses, in order to comply with the Scotland Yard standard of quietness, it was requisite to have a chain instead of a spur drive. With the greatest possible care in shaping the teeth of spur gears they could be made to run fairly quietly for a time, but after wear they became noisy, and in that respect the inverted link type of chain drive had a very marked advantage, and was the only kind of gear-box which had proved successful for bus work in respect to quietness. The speaker believed that the petrol-electric transmission was really devised to overcome the difficulty of the noise of the ordinary spur gear-box, but to the speaker's mind the chain gear-box had rendered the petrol-electric system, with its extra complication, unnecessary for the attainment of the variable speeds.

The next speaker, Mr. Parnacott, considered that there was one aspect of the translation of energy from the engine to the road wheels which had been overlooked, namely, the efficiency of the transmission. The prime object of interposing a variable gear was to give a variation of the quantity of fuel consumed per ton per mile; 60 to 65 litres of mixture would give one horse-power, depending upon how many litres could be consumed in a given time. It was this consideration which rendered necessary the introduction of change-speed gear. Distribution of weight, in view of propulsion of the vehicle over very bad surfaces, was another matter of importance; in mounting steep gradients, for instance, sufficient weight must be impressed upon the driving wheels. For military purposes a transmission was requisite which avoided the application of universal joints. The speaker regarded the hydraulic gear as suffering from the fundamental disadvantage that the speeds of the motor, pump, &c., were so low that it was necessary to introduce some speed gear in order to obtain sufficient torque. He would assume that no mistake had been made in the dimensions of the chassis, but, from the illustrations in the appendix to the paper, it seemed that the oil motor weighed as much as the petrol motor. The weight tended, accordingly, to be excessive, particularly when consideration was given to gear reduction, the ratio of which appeared to be 4:1 as a maximum. Apparently the speed of the motor was 160, the wheels making 10 revolutions per minute, equivalent to 1 mile per hour. That was a low speed variable. For transmitting the energy from the motor to the four wheels, there seemed to be only the alternative of the petrol-electric drive. In view of the proved success and many advantages of the latter system, he could see no reason why it should not be developed so as to displace the sliding gear transmission; the changes of speed with the petrol-electric system were gradual rather than in steps. The figure of 90 per cent. or more for motor vehicles fitted with sliding gear was only correct if it referred to makes. There was, for instance, a large number of Ford cars fitted with epicyclic gear, and these were quite successful. He considered the volume of charge burned per ton-mile, to which he had alluded, to be the crucial point. The Ford car consumed a large amount of petrol vapour, and, consequently, the average performance was something like 25 to 30 miles per gallon of petrol. With a chassis weighing 14 cwt. the expectation would be 35 miles. The fuel consumption was high because the drive was on the throttle. It was possible to design a vehicle which would have no change-speed gear, provided an engine of sufficient size was fitted. Friction clutches being tolerably satisfactory, the start could be made on the top gear.

[Dr. Hele-Shaw here remarked that the 90 per cent. he had mentioned was for the step by step system, including the epicyclic gear.]

Mr. H. J. Thomson stated that Mr. Thomas, whose transmission system had been referred to, was prevented by illness from attending, but would send a written communication. Meanwhile, he would say, with regard to the Owen magnetic system, described in the paper under "Germain Electric System," that a large proportion of the torque of the engine was always transmitted mechanically; there was no positive action, but a magnetic action. Further, the Thomas system shared with the Germain system the characteristic of dealing with a large proportion of the power, while the Thomas system had a direct mechanical drive on top. It was not necessary to go to America for the "points" of the Owen machine. Referring to Mr. Clarkson's suggestion that the change-speed gear-box had practically rendered unnecessary the petrol-electric and hydraulic systems, the question of efficiency had to be borne in mind, and the fact that it was necessary to secure a wide and flexible range of torque without loss of power. With regard to driving on all four wheels, the speaker selected as an instance of this possibility a road train which had been running in London for some time, electric power being transmitted to every wheel of a train of three vehicles. In this respect, certainly, the petrol-electric system had an advantage not possessed by other systems.

Mr. C. R. Opperman desired to comment upon the construction of the ordinary sliding gear-box, which he regarded as the best existing gear for all intents and purposes. Mr. Phillips had attributed the success of the sliding gear to the high speed of the motor and the greater attention devoted to that class of gearing. A third factor of success, however, was in the hardening of the alloy steels used. As bearing upon the question of noise, he would say that, owing to the unique position he occupied, thousands of gears which had to be rejected on account of repairs passed through his hands in twelve months. He could therefore make some suggestions as to the defects in sliding gears. The author had suggested that peripheral speed should be kept as low as possible, but the speaker would urge that this speed should not be so low as to introduce pinions with a small number of teeth. Pinions with 12, 13 or 14 teeth were frequently seen. But, with such a pinion, the angle at which the teeth of the pinion had to drive the wheel was very great, some 30 deg. While this might not greatly affect pleasure cars, it was of importance in relation to commercial vehicles, frequently required to run at first speed under a heavy load, and pinions with few teeth should be avoided, when practicable. He would like to refer to the practice of introducing stub teeth into the gear. These teeth were noisier than the standard, in evidence of which he would say that in a gear he had put on the market the teeth were apt to break, and in redesigning the gear he put in stub teeth; this course resulted in considerable noise. He then experimented by putting together two pairs of gears, one with standard and the other with stub teeth. He mounted the wheels on heavy shafts, purposely leaving them soft to avoid distortion. Nevertheless the stub teeth made considerably more noise than the standard teeth.

Mr. R. E. Phillips then replied to the discussion. Generally, to keep the paper within reasonable limits, he had avoided questions of constructional detail, such, for instance, as the construction or form of teeth. In regard to efficiency of transmission, the statement in the paper was not correct as printed, and he had, in reading, substituted for it the words "90 per cent. of the motor road vehicles as manufactured in this country. It was well known that Ford cars had been made and sold in numbers impracticable to estimate. As an answer to any criticism of omissions, he would plead the limitations of space. He agreed that the law of the "survival of the fittest" was particularly applicable to engineering matters, but he scarcely thought that law applied to the present predominant type of gearing; for, if so, no type but the sliding gear would exist. He accepted Dr. Hele-Shaw's correction of "automatic change gear"; as some mechanical movement had to be made by hand, the gear was only semi-automatic. The other term, however, was generally employed. Certainly, in comparison with such purely automatic transmissions as the hydraulic and petrol-electric, the transmission referred to was only semi-automatic. He believed that the Owen magnetic system had never been introduced into this country. It was, apparently, however, precisely the same as the Germain system. It was unaccountable that this latter system, introduced some twelve years ago, had not achieved a greater commercial success, in view of its potentialities. As to the tests of the rapid acceleration of the Owen magnetic vehicle, he would suggest that what produced the skidding of the wheels was either a greasy road or a weight on the driving wheels insufficient to maintain adhesive contact. He agreed that the success of the sliding gear was attributable, in part, to the present methods of hardening and treating steel, but he thought the point covered by his remark, in the paper, that the success of the gearing depended upon a very high standard of workmanship and high-grade materials. He was much interested in Mr. Opperman's experiments with stub teeth.

The chairman then closed the proceedings by announcing that the next general meeting would be held on Friday, July 19, 1917, when a paper on "The Manufacture of Gauges at the Paddington School" would be read, and possibly also a second paper on "Gauge Manufacture."

THE TRADE OF CANADA.—We read in *Canadian Machinery* that the total value of the exports from Canada to Great Britain was 557,909,000 dols. for the 12 months to end of last June, as compared with 209,609,000 dols. for the 12 months ended June, 1914; the total value of the imports from Great Britain was 90,275,000 dols., as compared with 121,461,000 dols. for the same period. Trade with the United States showed an increase of nearly 74,000,000 dols. in imports and of 117,865,000 dols. in exports during the years under consideration. The imports increased from 363,117,000 dols. in 1914 to 442,088,000 dols. in the year ended last June; the exports increased from 182,575,000 dols. to 300,440,000 dols. Canada was buying 74,000,000 dols. worth of goods a year more from the United States and 31,000,000 dols. worth of goods less from Great Britain than was the case two years ago.

LITERATURE.

Bridge Engineering. By J. A. L. Waddell, D.Sc., M.Inst.C.E. New York: John Wiley and Sons, Inc.; and London: Chapman and Hall, Limited. Two Vols. [Price 42s. net.]

Books on structural engineering make their first appearance more frequently in America than in this country, and, as a rule, they are valuable additions to the literature of the subject. The wider field open to American engineers does not fully account for this numerical superiority. It is due in a great measure, we think, to the freer intellectual intercourse and enterprise, and a more frequent collaboration of authors, in America than here. These are creditable features. On the other hand, while in this country generous recognition is given to American accomplishment, it cannot be said that this attitude is reciprocated.

The occasion of these remarks, not intended as wholly applicable to it, is the publication of Dr. J. A. L. Waddell's "Bridge Engineering." The author is a distinguished American bridge engineer, a pioneer in his profession, and an eminent writer on bridge engineering. In this book, with the help of his assistants, he has given freely of the fruits of a long professional life. The germ of it will be found in the same author's "De Pontibus," published first in 1898, and again in 1903. Since the first appearance of "De Pontibus," material for the much larger "Bridge Engineering" has been accumulated, and the comparative leisure resulting from the war has enabled Dr. Waddell to hasten its completion. The two volumes run together to more than 2,000 large octavo pages.

The first volume opens with chapters on the evolution of bridge engineering and on the bridge specialist. The former is a notable contribution to the history of bridge engineering. From conjectural forms the author passes to early authentic constructions, and briefly traces the evolution to the present time. As noted, there has been collateral development in form and materials, and in methods of design, fabrication and erection. The specialist is a natural consequence of the development. The qualifications of the ideal specialist are enumerated. An appreciation of these should serve to correct any misapprehension as to the importance of the actual specialist.

Ordinary materials of bridge construction and alloy steels in bridgework are considered in the third and fourth chapters. The latter treats of the properties of various alloy steels more or less suitable for bridges, including nickel, Mayari, purified, vanadium, and silicon steels. It deserves close study. The transition from wrought iron to the general use of mild steel about 1890 was accomplished easily, but progress in the adoption of alloy steels has been disappointing. Of these, nickel steel is the most prominent. Dr. Waddell makes no direct mention of the occasional irregularity in its composition noticeable in tooling, nor of the increased deflections resulting from the higher unit stresses permissible. Both are objectionable, and the latter is a cause of increased secondary stresses. The increase of strength of nickel over carbon steel is put at 50 to 70 per cent., and this increased strength for weight extends the practicable limiting span for steel bridges. This length, we read, may be extended fully 500 ft. in cantilever bridges. If 1,800 ft. be regarded as the maximum length of such spans in carbon steel, then 2,300 ft. would be the corresponding length in nickel steel. Below the lower limit the comparison is an economical one. In reference to this, curves are given from which the weights of nickel and carbon steels in different spans may be obtained, and also curves showing comparative costs of spans for various excess unit prices of nickel over carbon steel.

Five chapters deal with loads—dead, live and impact loads, effects of track curvature, and wind, vibration and traction loads. Based upon data regarding present and prospective live loads which he has collected, Dr. Waddell has adopted new standard loads for railway bridges. These are tabulated, and curves derived from them are given for maximum end shears and equivalent live loads. Similar curves are given for electric railway and highway bridges. The preferable way to take account of the shock effects of live loads is to add an allowance for impact to these loads and so obtain an equivalent dead load. The difficulty, all factors considered, is to arrive at an appropriate impact formula. Recent experimental results have led to the revision of existing formulæ, and Dr. Waddell presents his revised formulæ for steam railway, electric railway, and highway bridges, which give reasonable results. Derived curves are given showing the coefficients of impact for various span lengths for different classes of bridges.

The tenth to the fourteenth chapters have reference to stresses, and treat of methods of stress computation; secondary, temperature and indeterminate stresses; deflections, combination of stresses and intensities of working stresses. As a whole, these chapters do not supersede the standard text-books, but rather supplement them, and guide the student in their use and in the acquisition of time-saving expedients. Emphasis is laid on the area-moment method for calculating deflections in certain cases, and the use of the Williot and Williot-Mohr diagrams in ascertaining truss deflections is explained.

First principles of designing, 50 in all, are enunciated in the fifteenth chapter, which the author considers the most important in the book. These will receive general acceptance. Detailing equivalent to the full section of a main member (xxvi) may be questioned, since sections are often unavoidably excessive. The disapproval of star struts formed of two angles, and the reason therefor (xli) should be noted, as this form is favoured.

Detailing in general, shopwork as affecting bridge design, and classes of traffic, are separately discussed. The majority of failures have been due to defective detailing, and, further, detailing is the most difficult part of design. The chapter devoted to this subject is therefore an important one. References to it would have been facilitated by sub-headings.

The design of floors and floor systems, laterals and sway bracing, and of the various types of bridges is fully considered. These types comprise plate girder, rolled beam, and simple truss bridges; trestles, viaducts and bridge approaches; elevated railroads, cantilever, arch and suspension bridges. There are fashions in engineering, and cantilevers have had a vogue which is now somewhat restricted. As Dr. Waddell points out, they are eminently suitable where falsework cannot be used for erection, but they are inferior in rigidity and usually require more metal than simple spans up to about 600 ft. Relative economic span lengths are discussed. Many curves are given here and later in the book concerning weights of cantilever bridges. It is claimed that these give the most accurate data yet published. The advantages of the steel arch are a good appearance and a possible economy of metal, but there is a lack of rigidity and, for most types, uncertainty as to stresses. The relative merits of eight types are summarised. Formulæ are given for finding approximate weights of metal in arches prior to designing.

Four chapters are devoted to movable bridges in general, and to swing, bascule and vertical lift bridges. There is a useful diagram showing cost of power equipment. The statement that the cost of alternating-current equipment would amount to about 25 per cent. more than for direct-current is surely inaccurate. It depends on the number of phases, but should never reach anything like that figure. Besides, maintenance costs are much in favour of alternating-current machinery. Two errors of fact regarding transporters may be noted. The first transporter was built at Bilbao, not at Rouen, as stated. Bilbao Bridge dates from 1893 and Rouen from 1899. Again, there is only one transporter of 1,000 ft. span across the Mersey and the Manchester Ship Canal. Apparently the reference to the Widnes-Runcorn bridge of that span has been repeated in error.

A short chapter disposes of riveted *versus* pin-connected trusses, and then dimensioning for camber is discussed. Protection of metal-work, wooden bridges and trestles, and draw-bridge protection have separate chapters allotted to them. The thirty-seventh chapter, of 180 pages, is a considerable treatise on reinforced-concrete bridges, and should prove useful to engineers engaged on this kind of work. Little space is given to theory, because it is adequately treated in several text-books named, but fundamental assumptions are stated. Various formulæ, with derived diagrams, are grouped conveniently for use in designing elements and structures. Practical notes on construction are followed by specifications for design.

Seven chapters on foundations bring the first volume to an end. These are: foundations in general, cofferdams, open-dredging process, pneumatic process, piles and pile driving; piers, pedestals, abutments, retaining walls, and culverts; and shore protection and mattress work. When in doubt use compressed air, is a good maxim, and although the author has a commendable preference for the pneumatic process we think the chapter thereon might be amplified with advantage.

The second volume opens with a chapter on expedients in design and construction, followed by chapters on work preliminary to design. The subjects treated are data required for designing bridges, trestles and viaducts; locating and preliminary surveys, borings, determination of waterways, United States Government requirements, and hydrographic surveys. Much useful information and advice are given. We agree that any money spent legitimately on preliminary investigations is money well expended. Competitive designers, however, cannot bear the expense of exhaustive investigations, and often have to go ahead on meagre data, occasionally obtained surreptitiously.

Much criticism adverse to their appearance has been directed at steel bridges by architects and others less qualified to judge. We know that few designers are kin to Brunelleschi or Wren, and they are often further handicapped by imposed conditions. Nevertheless most of the criticism is mistaken, and therefore of little value. Designers and critics alike would benefit by a study of what is said concerning general symmetry, proportion of parts, ornamentation, functional efficiency and other cognate matters, in Dr. Waddell's chapter on aesthetics in design.

True economy of design, and determination of layouts receive attention. Weights of steel superstructures, and quantities for piers, pedestals, abutments, retaining walls, and reinforced-concrete bridges, are given in two chapters, and these will be very useful in designing and estimating. Estimates are considered in the fifty-seventh chapter, and office practice in the fifty-eighth. Comprehending as it does methods of work and the systematic compiling and recording of data, office practice in this country does not receive adequate attention. Dr. Waddell gives in detail the practice, gradually evolved, of his own office. This is valuable both in itself and as matter for comparison. A reference is made to Mr. John P. Davies's "Engineering Office Systems," a book which deserves to be better known.

The significance of the proper inspection of materials and workmanship justifies the space given to the chapter on inspection. Fieldwork is dealt with in chapters on triangulation, engineering of construction, erection and falsework, maintenance of traffic, bridge examination and reconstruction, maintenance and repairs. Our experience is that sufficient care is not always exercised in sinking caissons correctly, for which frequent and systematic surveys are necessary. Attention may be called, therefore, to the method of locating the position of a caisson during sinking (pages 1,472 *et seq.*), and report sheet (page 1,492) for recording the progress of the work.

The status of highway bridge building in the United States, about which the author has some plain things to say, is considered in the sixty-fifth chapter, and bridge failures and their lessons in the next. Several chapters are devoted to the more purely business affairs of bridge engineering, comprising specifications in general, contracts, reports, administration of construction, arbitration, promotion of bridge projects, fees, some business features, responsibility of the bridge engineer and ethics of bridge engineering.

The second volume is brought to a close, except for an interesting glossary of terms, by general specifications governing design, and the same governing manufacture and erection. Both are full and explicit. The former is a very complete guide

to the preparation of plans and specifications. The clauses of the latter are distinguished as permanent (P), variable (V), and incomplete (I), which indicate the manner of their use.

It will be gathered from the preceding sketch of its contents that the book is comprehensive and ambitious. Although many of the chapters might be expanded into monographs, there is no lack of detail or evidence of perfunctoriness in any part, and technically the whole reaches a high level of excellence. The sequence of the chapters is natural, each is built up in a logical and also interesting way, and the writing is clear and on occasion vigorous. Younger men should find this book stimulating, but we think that it will make its strongest appeal to practising engineers, whatever step on the ladder they may have reached. To them it can be recommended with confidence. The publishers have done their part well, and have produced a book which is pleasant both to read and handle.

Arithmetic for Engineers, including Simple Algebra, Mensuration, Logarithms, Graphs, and the Slide Rule. By CHARLES B. CLAPHAM, Hons.B.Sc.Eng. (Lond.). London: Chapman and Hall, Limited. 1916. [Price 5*s.* 6*d.* net.]

THIS work, one of the "Directly Useful Technical Series," belongs to the class to which the term practical can be applied, for the examples are selected with the view of fixing the student's attention on the affairs of ordinary life, and it does not concern itself with those ingeniously constructed propositions which may exhibit the craft of the finished arithmetician, but are of little assistance to the struggling pupil. In the author's words, "the examples are problems actually met with in the drawing office, workshop and laboratory, while the data are of correct dimensions." Such a common-sense process must command approval, and one rejoices to meet a teacher who recognises that arithmetic is only a means to an end, a tool to be used deftly in order to accomplish the largest result with the smallest exertion possible. In this spirit the work is pursued, many of the examples being referred to simple forms of mechanism on which the dimensions are marked, thus not only dispensing with much description, but, by making the student familiar with plan and elevation views of the same object, assisting in promoting a correct appreciation of engineering drawings. This is excellent. Arithmetical conundrums that perplex without edifying are the invention of examiners who pride themselves on their powers of puzzling candidates, and teachers unfortunately have had to adopt wrong tactics to foil these pernicious requirements. The ingenuity displayed by students to meet these tortures is often as cunning as it is painful. They have evidently learnt something, though it may not be arithmetic, and that they do succeed in solving the problems is evidence rather of "a misspent youth" than of well-organised teaching.

In another direction, however, the author seems to have missed the mark. He has been too much afraid to break away from old traditions and respected authorities. Vulgar fractions have occupied much space in all arithmetics from the days of Cocker, and Mr. Clapham follows on the same lines, failing to give the decimal notation its due importance at the earliest stage. Instead of dragging in a complicated machinery of least common multiple, leading to common denominators, the relics of a departing system, we should much prefer to see the vulgar fraction turned at once into a decimal and as many places retained as the problem needed. The affection many entertain for the more complex form is pathetic, and the author seems to pander to this habit. We remember a very careful joiner who would measure a length as $\frac{3}{8}$ in. and half a sixteenth, and could never be convinced that four-tenths of an inch meant for him the same degree of accuracy, and the author seems willing to foster this antiquated form of thought by adhering to a vicious groove.

It would seem that Mr. Clapham is not too well affected towards the decimal system; but he would have acted wisely in insisting on the adoption of those weights and measures which have become common in international use. Money problems do not come before him to any great extent, and the question of uniformity in international currency—so often confused with metric measurement—need not have been raised. The metric system in electricity, physics and chemical work is very generally adopted, and its convenient notation is obtaining wider recognition wherever the units of length, weight and capacity enter. As a device for shortening arithmetical operation it is only second to the invention of logarithms, and no opportunity should be lost of insisting upon its use. It is heart-breaking to be forced back upon the old convention of "$5\frac{1}{2}$ yards equals one rod, pole or perch," and to find that the still more monstrous factor of $30\frac{1}{4}$ is retained as part of our national system of weights and measures. It is fortunate that problems in cubic content avoid this cumbrous notation, as the most expert computer would recalcitrate against the infliction of such a barbarous proceeding.

The author does not insist on the pursuit of an exactness that serves no useful purpose, and therein we think he is right, though possibly he carries the methods of approximation further than many will approve. His object is not to teach children numerical accuracy, but to teach engineers and workmen how to obtain a satisfactory result. At the same time we doubt on general grounds whether the saving effected by making fewer figures compensates for the time lost in determining how far a contraction may be legitimate. The use of a smaller number of figures is thought to be very meritorious, but, to take an example, most people will divide a number by two and the quotient again by two in shorter time than they will divide the original number by four. So when those who are unaccustomed to arithmetical calculations think they will save time by some ingenious contraction, they will usually find that the better course would be to carry the computation through and throw away the unnecessary figures. This remark applies more particularly to isolated cases. If the method is one that is frequently repeated, the process becomes quite mechanical and the advantage is on the side of contraction.

The remarks on the symbols and processes in elementary algebra appear sound and useful, though perhaps spread out to rather wearisome lengths, and some of the illustrations on the simple transformation of formulæ seem unnecessary, as it can make no difference on which side of an equation the unknown stands, but doubtless, as an experienced teacher, Mr. Clapham knows that there is some advantage in uniformity of arrangement which is not apprehended by those not similarly engaged. In the same way, it seems immaterial whether a log. or an antilog. is taken from a particular column of a table, the small amount of interpolation is the same in one case as the other, but in such matters it is wise to trust the expert. We are not prepared, however, to surrender our judgment in the choice of the form of characteristic to the logarithm of a decimal. One system has been adopted for the logs. of trigonometrical functions less than unity, and has obtained universal approval; the employment of another method in the case of numbers must lead to confusion. Mr. Clapham, we imagine, would have a difficulty in explaining to his class why the log. of 0.5 should be written in one case by $\bar{1}.697$ and in another 9.697. One of the two methods must be the more convenient, and though it is hopeless to expect any alteration in the direction of uniformity, it is curious to note the effect of habit.

Some useful chapters are given on mensuration, and the collection of related formulæ into convenient groups should be appreciated. Perhaps more, or less, should have been said about the periphery of an ellipse. If it be desirable to show that the formulæ become exact when the ellipse approaches the circle and the major and minor axes become equal, it would have been as well to have discussed the effect of making the minor axis exceedingly small. Very instructive lessons can be drawn from limiting cases.

To judge from the elaborate directions given for the management of a slide rule, it would appear to be a difficult tool in the hands of a tyro, but nevertheless we are grateful to the author for insisting on this adjunct to the multiplication table and the sheet of logarithms. Its use might have been carried further, and possibly every student should be compelled to make his own instrument. There are some remarks on the general theory which might have been extended with advantage, and the interest in working the rule would be greatly increased if it were the student's own handiwork. It would, too, call for or test that kind of accuracy which is very useful in the construction of graphs, to which the author devotes a chapter: a very favourite form of investigation, but one that for the neophyte is not without its dangers, on which Mr. Clapham might with judgment have laid more stress. The examples given in the book are so pretty, the points lie so near the curve, that the graceful sinuosity on which Herschel insisted seems quite easy of attainment. But the treatment of the points distant from a regular curve presents great chances of introducing mischievous error. To determine whether the deviations are due to experimental error and errors of manipulation, or traceable to real change in the conditions of the experiment, requires great caution and judgment. The degree of accuracy attainable in the graphical method is strictly limited, but the method can itself lead to errors quite comparable in magnitude to those that arise in careful experiment. Students should be taught to estimate the errors in measurement of the abscissæ and ordinates of the initial points as well as those read off from the curve. If the accuracy needed exceeds $\frac{1}{1000}$ of the quantity measured a geometrical solution is probably to be preferred. Again, if the ruled ordinates deviate but one minute from the perpendicular—and that is a very small quantity—the measured abscissa will be in error $\frac{1}{3400}$ of the length of the ordinate. Graphs look more trustworthy than they are, and a word of caution to the beginner would not be out of place. But perhaps it is too much to expect that an author should throw any doubt or discredit upon a process that he recommends. The part of the teacher is to dictate, not to discuss.

BOOKS RECEIVED.

Telegraphy: a detailed Exposition of the Telegraph System of the British Post Office. By T. E. HERBERT, A.M.Inst.E.E. Third Edition, thoroughly revised and enlarged. London and New York: Whittaker and Co. [Price 9*s.* net.]

United States Bureau of Mines. Technical Papers. No. 122: *Effects of Atmospheres deficient in Oxygen on Small Animals and on Men.* By GEORGE A. BURRELL and G. G. OBERFELL. No. 123: *The Sand Test for Determining the Strength of Detonators.* By C. G. STORM and W. C. COPE. No. 145. *Sensitiveness to Detonation of Trinitrotoluene and Tetranitromethylanlin.* By GUY B. TAYLOR and WILLARD C. COPE. No. 151. *Coke Oven Accidents in the United States, 1915.* By ALBERT H. FAY. Washington: Government Printing Office.

United States Bureau of Mines, Bulletins. No. 92: *The Feldspars of the New England and North Appalachian States.* By A. S. WATTS. No. 93: *Miners' Nystagmus.* By FREDERICK L. HOFFMANN. No. 96: *The Analysis of Permissible Explosives.* By C. G. STORM. No. 115: *Coal Mine Fatalities in the United States, 1870–1914.* Compiled by ALBERT H. FAY. Washington: Government Printing Office.

The Journal of the Municipal School of Technology, Manchester. A Record of Investigations undertaken by some Members of the Manchester School of Technology during the Year 1914. Vol. viii. Manchester: School of Technology.

Excess Profits (including Excess Mineral Rights) Duty and Levies under the Munitions of War Acts, Incorporating the Provisions of the Income-Tax Acts made applicable by Statute and by Regulation, also the Regulations of the Commissioners of Inland Revenue and of the Minister of Munitions. By W. E. SNELLING. Second Edition, Revised and Enlarged. London: Sir Isaac Pitman and Sons, Limited, 1, Amen Corner. [Price 10*s.* 6*d.* net.]

United States Department of Labour. Bulletin No. 187. *Wages and Hours of Labour in the Men's Clothing Industry, 1911 to 1914.* No. 194. *Union Scale of Wages and Hours of Labour,* 1915. Washington: Government Printing Office.

THE NEW FINNISH-AMERICAN LINE.—The new Finnish-American line, which is to begin operations as soon as the war has come to an end, is meeting with much support. At the statutory meeting the new company has been termed the Finland-America Line. The steamers will start from Helsingfors, and perhaps Petrograd, calling at Hangö, and from there proceeding direct to New York by way of the Kiel canal, provided the necessary permission can be obtained. The question of tonnage naturally gives some trouble, but pending the completion of the company's own new vessels, other boats will be employed on time charter. The company intends to build two or three emigrant boats of 12,000 to 14,000 tons, and five cargo steamers of about the same size.

600-B.H.P. TWO-STROKE CYCLE DIRECT-REVERSIBLE DIESEL MARINE ENGINE.

CONSTRUCTED BY THE LUDWIG NOBEL COMPANY, LIMITED, ENGINEERS, PETROGRAD.

Fig. 2.

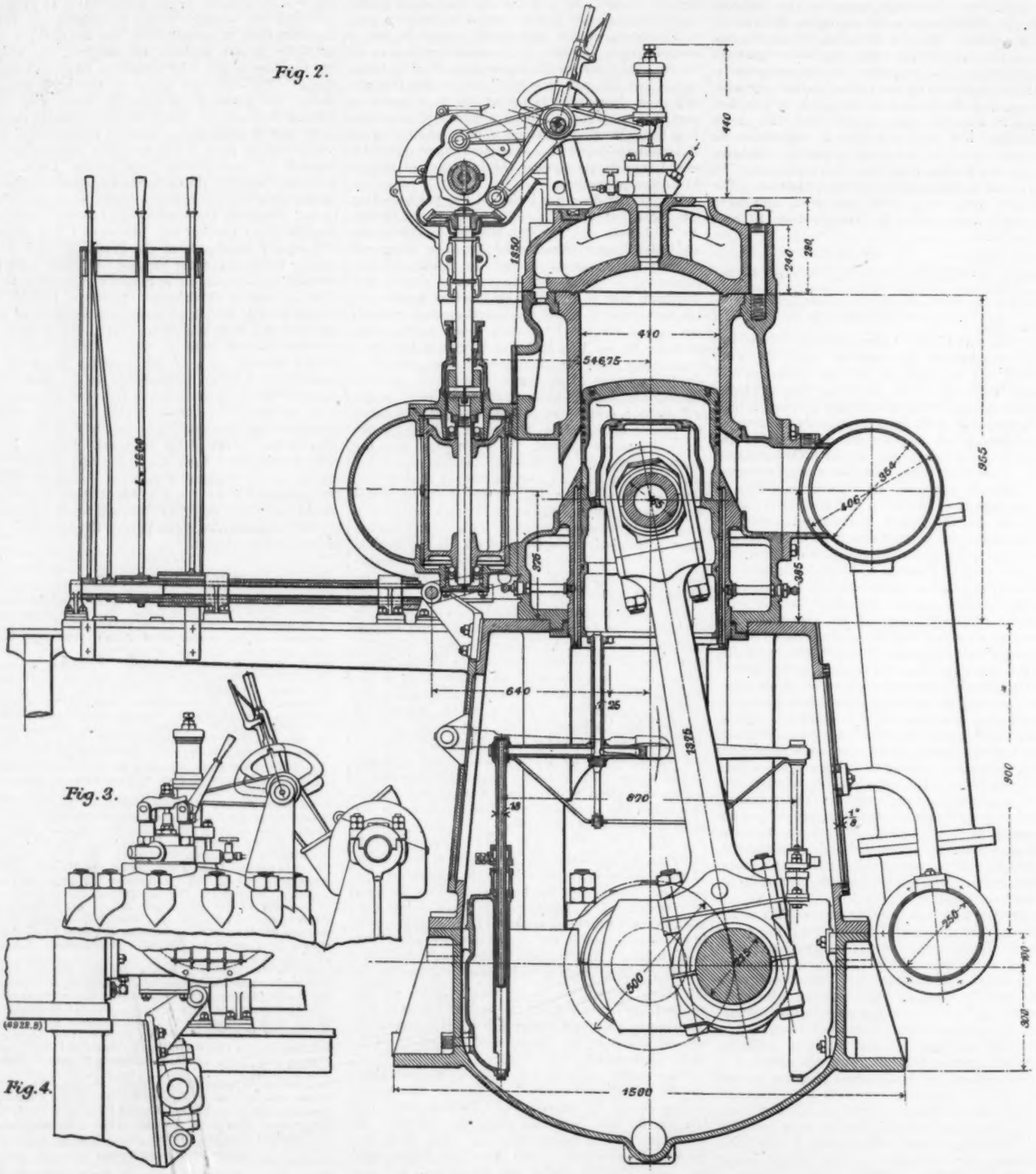


Fig. 3.

Fig. 4.

TRIAL OF A 600-B.H.P. TWO-STROKE DIRECT-REVERSIBLE NOBEL DIESEL ENGINE.

By Baron G. Steinheil, B.Sc., Petrograd.

The following is a brief description of a set of Diesel engines built by the Ludwig Nobel Company, Limited, at their engine works, Petrograd, for the twin-screw motor-ship Imperatriza Alexandra, belonging to the Caucase and Mercury Steamship Company and employed by that firm on their mail service on the Caspian Sea. Several years ago, owing to a considerable rise in price of oil, the Caucase and Mercury Company decided to adopt internal-combustion engines for their ships on the river Volga and Caspian Sea. Four-stroke cycle direct-reversible Diesel engines were selected for their river boats, these being then regarded as more economical than the two-stroke type, whereas the ships employed on the Caspian Sea were to be provided with engines working on the two-stroke cycle, as economy in fuel consumption was not so essential. As will be seen later; however, the Nobel two-stroke engines were found to be as economical as those working on the four-stroke cycle. The river boats had to be built entirely new, with two sets of six-cylinder 600 brake horse-power direct-reversible Diesel engines, as screw propulsion was decided upon, while the old vessels had side paddles. The sea-going ships, on the other hand, had their steam engines removed and Bolinder engines installed in the smaller ships, Diesel engines being provided for the larger ones. The engines now under consideration work on the two-stroke cycle and are reversible. They are direct-coupled to the propeller

600-B.H.P. TWO-STROKE CYCLE DIRECT-REVERSIBLE DIESEL MARINE ENGINE.

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(*For Description, see opposite Page*)

Fig. 5.

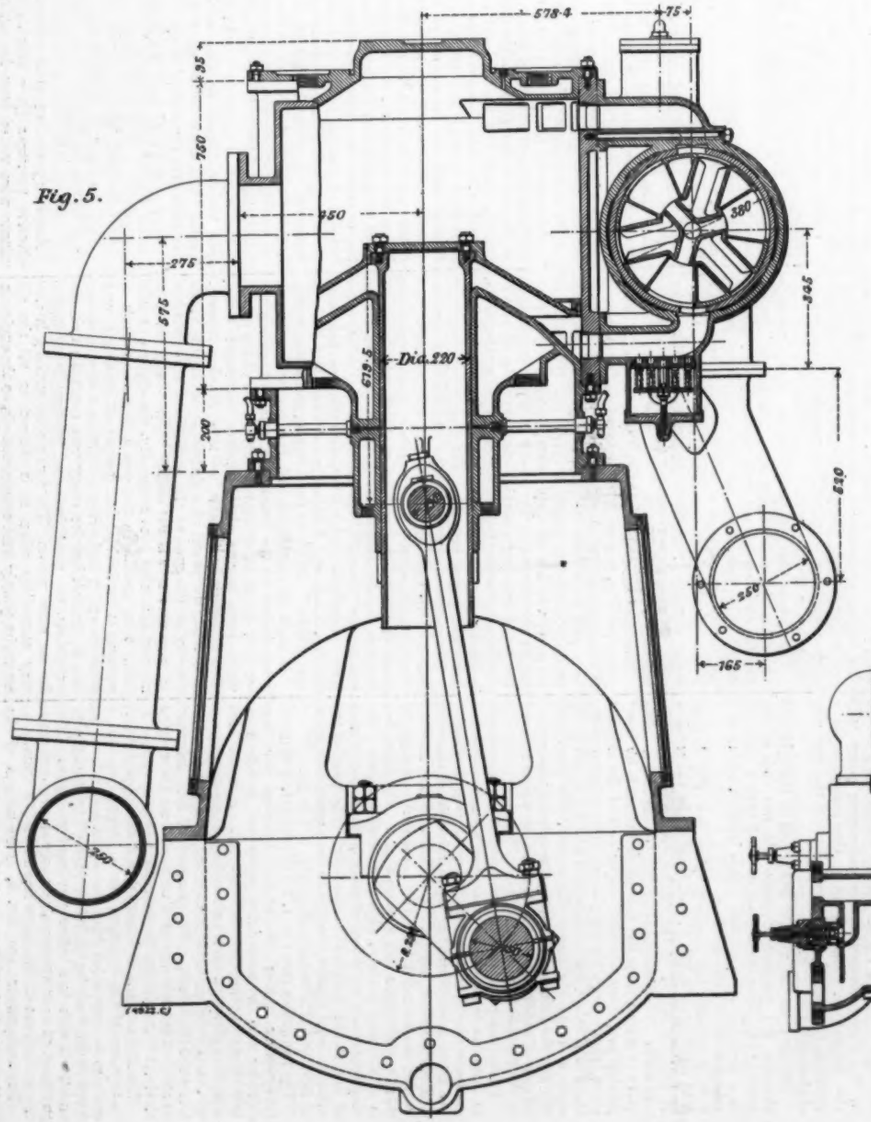
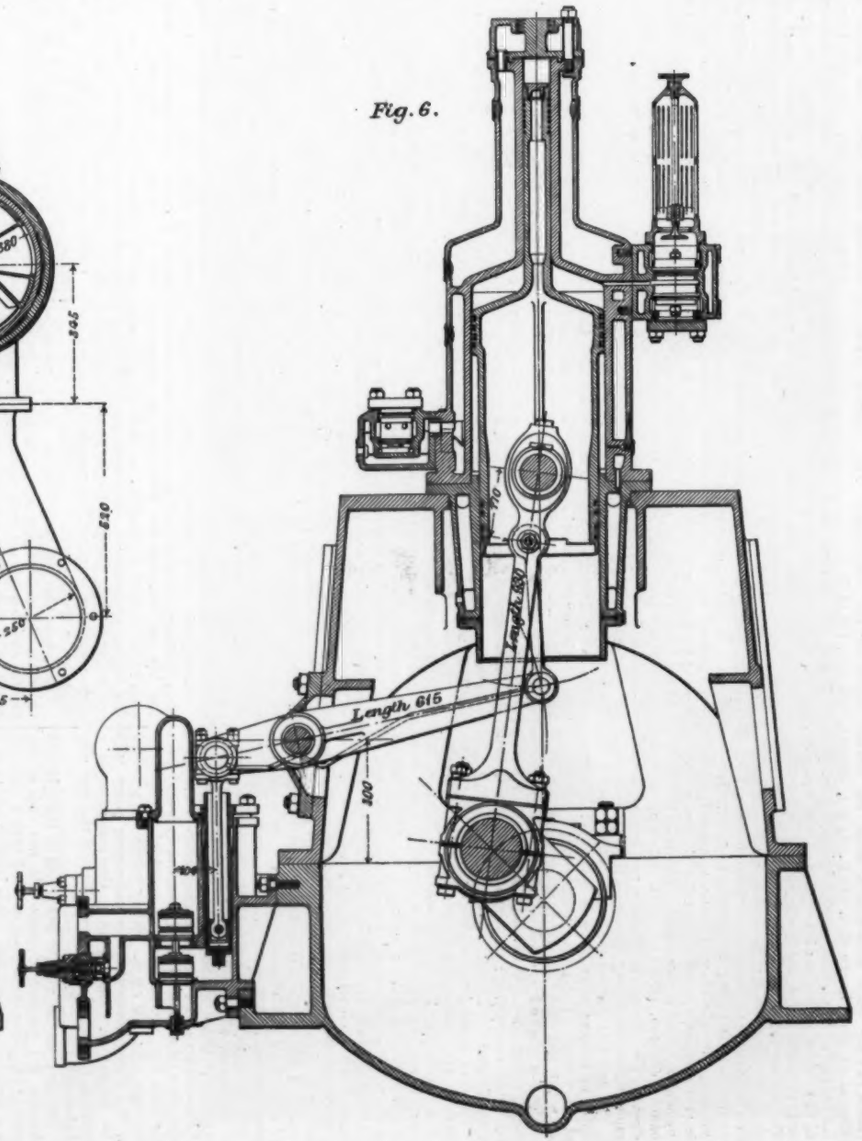


Fig. 6.



shaft, but the coupling bolts can be withdrawn quickly when necessary.

The engines are illustrated on Plate XLVIII, published this week and also on pages 608, 609 and 611. The weight of each engine is about 32 tons, making 53 kg. (116.8 lb.) per brake horse-power, while the overall dimensions are: length 6 m. (19 ft. 8¼ in.), breadth 1.5 m. (4 ft. 11 in.), and greatest height 2.6 m. (8 ft. 4¼ in.) Each engine has four cylinders cast separately and mounted on a crank-case of the enclosed type. The cylinders, as well as the crank-case and the bedplate, are of cast-iron; the cylinders are connected to the bedplate by five pairs of through bolts 3 in. in diameter, thus giving a very rigid construction and relieving the crank-case of tensile stresses resulting from the pressure on the pistons, the crank-case remaining under lateral stresses only. The cylinders have a bore of 410 mm. (16.14 in.) with 500 mm. (19.9 in.) stroke. The normal revolutions per minute are 210, each engine developing 600 brake horse-power.

The cast-iron pistons are each a single casting, the upper and lower parts being in one piece. They are of trunk type, serving also as guides, as no crossheads are fitted, and they have seven piston rings, six above the piston pin and one below. These pistons can be withdrawn from below without disturbing the heads of the cylinders or piping; they are water-cooled and have convex tops.

The scavenging air is supplied by means of a separate double-acting scavenging pump (see Fig. 5, page 609) at a pressure of 1.6 lb. per square inch gauge, this pump having a bore of 710 mm. (27.95 in.) and stroke of 500 mm. (19.9 in.), its volume being 1.4 times that of the working cylinders. The scavenging air can be taken either from the outside atmosphere or from the engine-room—in both cases the air has to pass through a special silencer, reducing the noise of suction. When the air is taken from the engine-room the pipe connection with the outside atmosphere is closed by a valve, or *vice versa*. This arrangement is very convenient when running in hot weather, as the air can be taken from the engine-room, thus creating a better ventilation of the latter, whereas in winter time the air can be taken from the outside, keeping the engine-room warmer.

The suction air for the scavenging pump is controlled by a rotary distributor driven, as shown, by helical gearing from the vertical shaft at one-third the speed of the engine, *i.e.*, 70 r.p.m. Safety valves are provided in the piping connecting the scavenging pump with the distributor. The air from the pump enters a receiver, running along the cylinders on the near side of the engine.

The air from the receiver has access to the cylinders through five scavenging ports. At the end of the receiver is a thin brass plate covered with a wire net at a distance of about two inches from it, acting as a safety valve for the receiver.

Each cylinder has a rotary valve (see Fig. 2, page 608) running on S. K. F. ball bearings in the receiver at half the speed of the engine and controlling the admission of scavenging air to the cylinder. This valve is driven from the half-speed camshaft by bevel gearing and opens when the upper half of the exhaust ports is uncovered by the piston. The exhaust ports, three in number, are water-cooled and are at about the same level as the scavenging ports. The gases pass through the exhaust ports into the exhaust pipe on the off side of the engine and hence into the silencer placed in the funnel of the boat.

The cylinder heads are of cast steel and are very simple in form, as each has only one working valve—the fuel needle valve. There are two other valves in the head—the starting valve and the safety valve, fitted also with a decompression handle. The fuel and the starting valves are actuated from the half-speed camshaft by double-nosed cams and rocking levers. The pulveriser is of standard pattern, with perforated washers. The diaphragm has six holes, ensuring uniform distribution of fuel in the combustion chamber. The part of the cylinder head forming the top of the compression space is concave. The compression ratio is 1 to 14.

The fuel pump (see Fig. 1, Plate XLVIII, is situated transversely across the engine between the first cylinder and the scavenging pump and is driven by helical gearing from the vertical shaft. It is provided with four plungers, each actuated by a separate eccentric, thus every cylinder is supplied with fuel from its corresponding pump. The amount of fuel delivered to the fuel valve is regulated by hand from the starting platform through suitable links and levers.

The fuel pump is so arranged that the supply of fuel to any one of the cylinders can be stopped at will, it can also be uncoupled from the engine and rotated by hand to drive all the air bubbles out of the fuel piping and fill it with fuel before starting the engine. The governor, of Jahn's pattern, acts only as a cut-out when the revolutions of the engine rise above 270 r.p.m.

The compressor (see Fig. 6, page 609) is of the three-stage type with a stepped piston, the upper part of which, working in a cylinder of 70 mm. (2.76 in.) diameter, provides for the high-pressure air, while the centre portion of the piston works in the low-pressure cylinder, with a bore of 330 mm. (13 in.), and the intermediate pressure side is below the low-pressure one and has a diameter of 295 mm. (11.6 in.), this arrangement reducing considerably the height of the compressor. The common stroke is 360 mm. (14.17 in.).

The air between the stages is cooled in a separate cooler, from whence it is conveyed to the starting and working reservoirs. The engine is also fitted with an additional compressor (see Fig. 1) for working the steering engine and some auxiliaries; this compressor has 220 mm. (8.66 in.) bore with 360 mm. (14.17 in.) stroke. It has an adjustable delivery valve, that can be regulated up to 10 atmospheres pressure. The normal pressure is 7 atmospheres gauge.

The crankshaft of the engines is in two parts, the main cranks and pump cranks, bolted together. The crankshaft, vertical shaft and all connecting rods are of Siemens-Martin steel. The vertical shaft is driven from the crankshaft by helical gearing.

The order of firing of the cylinders in direction from the compressor to flywheel is 1–3–2–4 for the starboard engine and 1–4–2–3 for the port engine, the propellers running outwardly.

The main cranks are at 90 deg.; this arrangement gives a balance of longitudinal forces, leaving only the rocking moment unbalanced, this moment having its minimum value. The cranks of the two compressors are at 0 deg. and at 180 deg. with the scavenging pump crank, this arrangement giving a balance of primary longitudinal forces of pumps after the weights of reciprocating masses and the distances have been properly selected, leaving an unbalanced inertia force of the second order having a very small value, as the weights of pump pistons are small, the strokes short and the connecting rods long. There is also a rocking moment, and to let that moment counterbalance as far as possible the moment due to the main cranks, the crank of the scavenging pump is placed at 45 deg., thus leaving a resultant moment of 4,880 m.-kg. (35,234 ft.-lb.) at 200 r.p.m. The crank position of the scavenging pump at 45 deg. ensures also a better scavenging of working cylinders.

All the main big end bearings are white metal lined. Main bearings, seven in number, are also water-cooled. The big end bearings are bolted to the connecting rods, having a plate in between, so that the compression height can be altered when necessary. The small end bearings are of phosphor bronze and the piston pins of case-hardened steel. The camshaft bearings are of phosphor bronze also.

The lubrication of the cylinders is by pressure, while the main bearings have gravity lubrication. The big end bearings get their oil supply through holes drilled in the crankshaft, the oil being forced there by the centrifugal action of the collecting rings. The piston pin bearings have forced lubrication, the oil being conveyed to them through oscillating steel pipes, these latter serving also as rocking levers for the indicator gear.

The cooling of the engine is by means of a water pump (see Fig. 6, page 609) situated on the off side of the engine near the three-stage compressor and driven by a side lever from the connecting rod of that compressor. Water is supplied to all the cylinders and air pumps, which are amply water-jacketed. The cooling of the pistons is by means of a telescopic gear, the water entering a special receiver on the off side of the engine, thence through a bridge piece to the piston, and returning to the near side by a similar arrangement and passing into the outlet pipe.

The gear for manœuvring the engines is all concentrated at the starting platform and is so arranged that one man can operate both engines. Each engine has three manœuvring levers 1.2 m. (3 ft. 11¼ in. long). Nearest to the engine is the starting lever, having notches for "Start," "Stop," and "Go." The outer lever controls the fuel, while the middle one has three notches, "Astern," "Ahead two-stroke," and "Ahead four-stroke." It serves for reversing and manœuvring.

It must be mentioned that this engine can be run when desired on the four-stroke cycle, *i.e.*, giving one working stroke for every two revolutions of the crankshaft, thus having the cylinders scavenged twice. This is especially suitable for slow running, because, in general, the power of a marine Diesel engine varies directly as the cube of the revolutions, and therefore at very slow speeds the engine is practically going at no load and often runs unsteadily, the chances of misfiring being great. In this case a four-stroke cycle of working is preferable, *i.e.*, instead of igniting a very small charge of fuel every revolution a double charge can be ignited, but for every two revolutions of the crankshaft, the mean indicated pressure being higher for the same power. The four-stroke working is also very convenient when it is desired to fill the air reservoirs quickly with compressed air, as the engine in the case of four-stroke working requires far less air for its running. An actual test was made, when an empty 250-litre air (88.3 cub. ft.) reservoir was pumped up to 60 atmospheres in six minutes at a rate of about 10 atmospheres for every minute.

The starting is on the two-stroke principle, for which operation, for ahead motion, say, the starting lever must be put on "Stop," (in which position the fuel and starting valve levers are shifted away from their corresponding cams, the fuel pump being cut out) the middle lever placed on "Ahead two stroke," if one wishes two-stroke working of the engine at once, and the fuel control lever shifted so much as found necessary for starting. Then the corresponding stop valves of the starting and working reservoirs are opened. These valves are situated on the platform near the levers, and the air passing through them reaches the manœuvring valve, the latter being actuated by the starting lever. In service all the stop valves of the air reservoirs are always open, the manœuvring valve opening and closing the reservoirs when necessary. The starting lever is next brought to "Start" position, and when the engine has acquired sufficient speed the lever is put on "Go," fuel is supplied to the cylinders, and the engine begins to work.

The speed of the engine is regulated by the fuel lever, and the revolutions per minute can be read off a tachometer driven from the vertical shaft. If a very slow speed is required from the engine the middle lever is shifted to the four-stroke position, shifting the cams and bringing a single-nosed cam against the fuel lever instead of a double-nosed one. If the middle lever is shifted to the four-stroke position while the engine is going full load two-stroke, the fuel lever is automatically shifted to a position corresponding to the maximum allowable for four-stroke working, so as to avoid a heavy overload on the engine. The engine can be brought to the four-stroke cycle at once after starting; for this purpose the middle lever must be put on the "Four stroke ahead" position from the beginning of the operation.

The reversing is also performed by shifting the cams, the camshaft being made hollow, the cam sets sliding on it sideways when actuated by the inner shifting shaft connected with the middle lever. Each cylinder has a set of five cams, placed on a common camshaft, the double-nosed cam being for two-stroke work and single-nosed for four-stroke. To reverse the engine it must be stopped, by bringing the starting lever to "Stop;" by this action the supply of fuel is cut off automatically. When the engine has stopped, the middle lever is put on "Astern," and the engine started in the usual way as described above.

Owing to the long profiles of the starting cams the engine can be started from any position of the cranks. The cam sets and gearing for the rotary valves are enclosed in cast-iron cases having hinged inspection covers.

The engine cannot be reversed while in forward motion, as the middle lever is so arranged that it cannot be shifted on "Astern" if the starting lever is not on "Stop." The shifting of the middle lever to the "Astern" position shifts the cams and brings a double-nosed astern fuel cam into action. When reversed the engine can only work on the two-stroke cycle.

The reversing of the engine from full load ahead can be performed in eight seconds. When the engine is started or stopped all four cylinders are put in and out of action simultaneously, but means are provided to cut out any one of the cylinders while the engine is working. This is performed by moving a handle situated at the end of the rocking lever shaft, this motion rotating the shaft and the fuel valve lever, sitting on an eccentric, is then brought out of action, the fuel needle remaining closed. The manœuvring cannot be performed with one or several of the cylinders out of action, and in case the engineer in charge of the engine were to forget to put the cylinder into action before the manœuvre, this is performed by the starting lever automatically, the latter coupling in the cylinder the moment the engine is stopped, and therefore no missing of starting can occur. As may be seen from the above description, the manœuvring of the engine is foolproof. A general view of the engine, prepared from a photograph, is given in Fig. 7, on page 611.

Description of Trials.

The object of the trials was to find out the performance of the engine working at different loads and speeds. The loads to be given were those having a mean effective pressure p_e of:—

(*a*) p_e = 4.8 kg./cm.² (68.27 lb. per sq. in.). Full load (normal).
(*b*) p_e = 3.0 kg./cm.² (42.67 lb. per sq. in.). Half load (about).
(*c*) p_e = 5.7 kg./cm.² (71.1 lb. per sq. in.). Overload.

For every one of these above-mentioned mean effective pressures (p_e = const.), the revolutions per minute were varied from 150 r.p.m. to 250 r.p.m. by every 25 r.p.m. Attention must be called to the fact that under mean indicated pressure p_i kg./cm²., is understood the mean ordinate taken from the

600-B.H.P. TWO-STROKE CYCLE DIRECT-REVERSIBLE DIESEL MARINE ENGINE.

CONSTRUCTED BY THE LUDWIG NOBEL COMPANY, LIMITED, ENGINEERS, PETROGRAD.

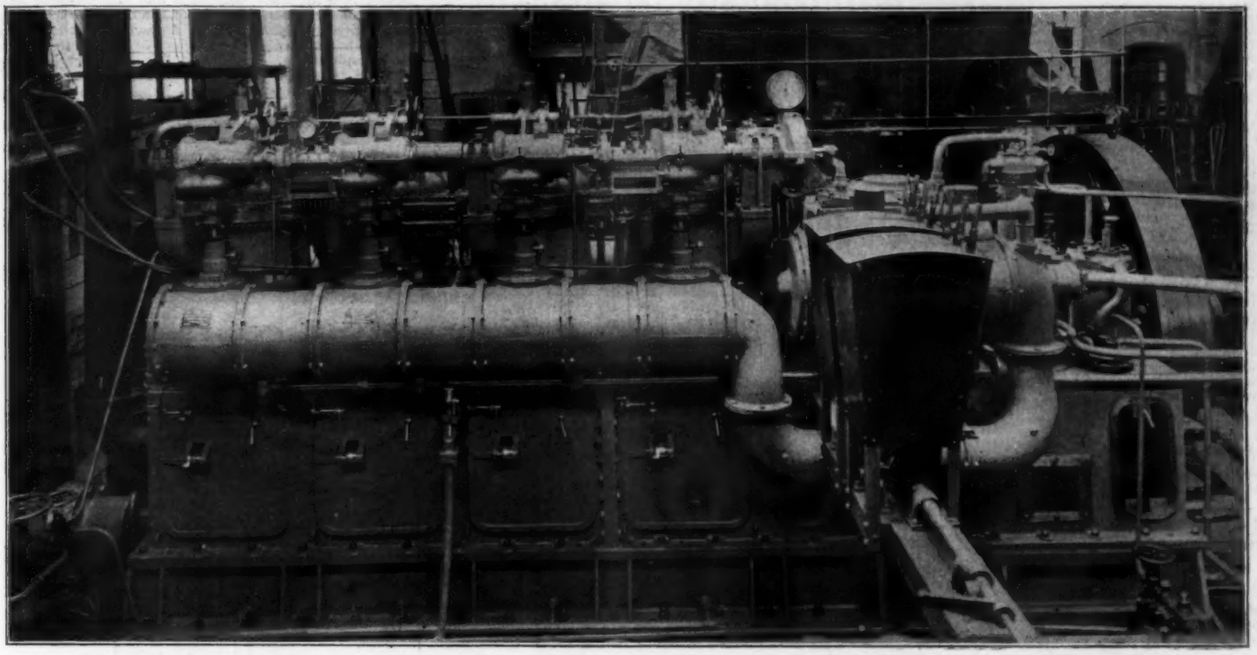
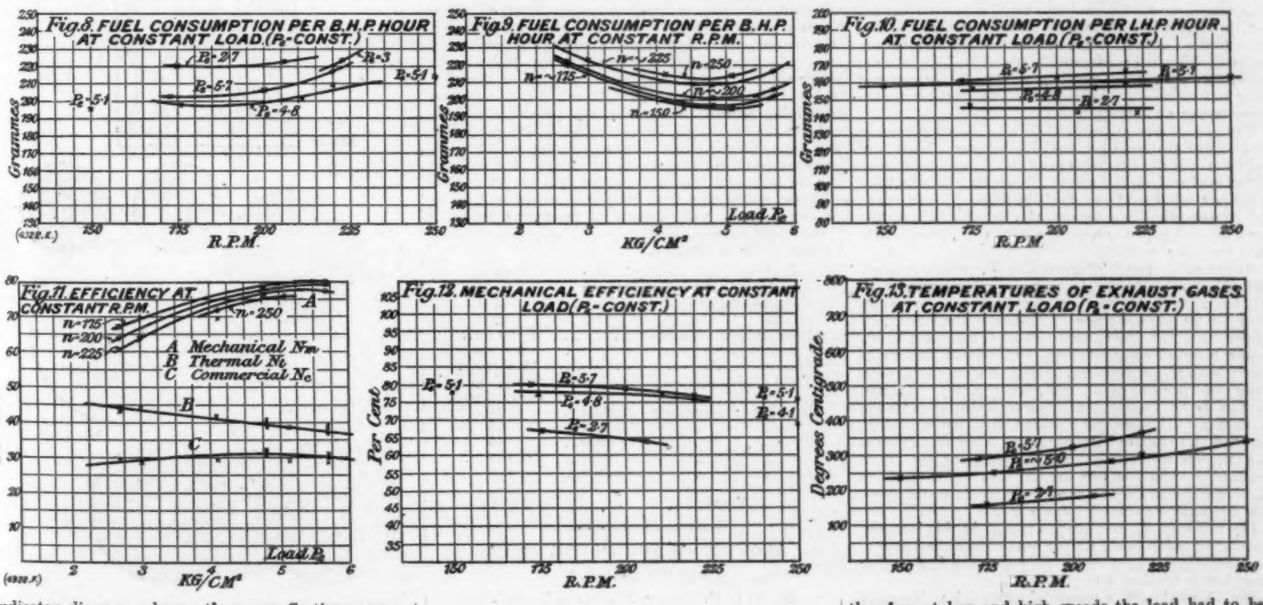
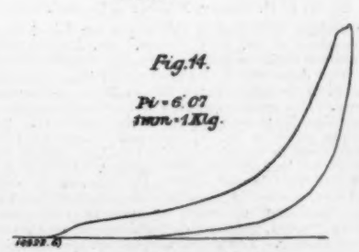


FIG. 7.



indicator diagram, whereas the mean effective pressure p_e kg./cm.² is the mean indicated pressure multiplied by mechanical efficiency N_m.

A series of preliminary trials were carried out to ascertain whether it were possible to get the above-mentioned loads at the given revolutions and also to find the best air-blast pressures for different loads. The engine was loaded by a Heenan and Froude water dynamometer No. 6 directly coupled to it. This brake was inspected before the trials by Professor W. Arshauloff, of the Petrograd Polytechnic Institute, Lieutenant-Engineer D. Philippoff, chief engineer of the Caucase and Mercury Steamship Company, and Mr. E. Elsberg, assistant to Mr. Philippoff, under whose strict supervision all the trials were conducted by the Nobel testing staff. The constant of the brake was calculated to be $N_e = \frac{W_{kg.} \cdot n}{300}$ and the brake weights were checked on a decimal balance.



As can be seen from the table of trials given on page 612, the programme could not be fulfilled completely, as the maximum power of the brake was 703 h.p. at 200 r.p.m., this varying as the cube of the revolutions, therefore at low and high speeds the load had to be altered, giving a different p_e.

The indicator diagrams were taken by means of Dreyer, Rosenkranz and Droop outside spring indicators of standard pattern. These indicators were calibrated before the trials for pressures of 10, 20 and 30 kg./cm.² (142 lb., 284 lb. and 427 lb. per square inch). The fuel consumption was measured by direct weighing on a decimal balance, three readings being taken during each trial, one final and two intermediate ones.

The number of revolutions during the time of fuel measurement was observed from a fixed revolution counter, the average revolutions per minute being then calculated. A Dr. Horn's tachometer was used only when a rough estimate of revolutions per minute was required. The scavenging air pressure was measured by a mercury manometer, whereas all the other pressures recorded were taken by ordinary Bourdon

TRIAL OF A 600 BRAKE HORSE-POWER TWO-STROKE NOBEL DIESEL ENGINE, SEPTEMBER 17 AND 18, 1915.

	Trial No.	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
1	Duration of trial ... ... min.	60	30	30	30	30	30	30	30	30	30	30	30	30
2	Load on brake W ... ... kg.	850	1000	475	475	850	1000	897.8	600	525	850	1000	725	897.8
3	Revolutions per minute ... ... n.	211	200	206	175	176.6	173	149	145.4	223	220	220	247.5	250
4	Mean effective pressure ... ... kg/cm² P_e	4.83	5.68	2.7	3.7	4.83	5.68	5.10	3.41	2.98	4.83	5.68	4.12	5.10
5	Brake horse-power ... ...(metric) N_e	598	667	326	276	500	577	448	291	391	634	733	598	749
6	Mean indicated pressure ... ... kg/cm² P_i	6.24	7.23	4.17	4.03	6.18	7.12	6.52	5.18	4.66	6.34	7.45	5.92	6.69
7	Indicated horse-power ... ...(metric) N_i	772	849	504	412	639	723.5	570.5	442.5	610.5	819.5	960	860	961
8	No load work ... ... $N_i - N_e$	174	182	178	136	139	146.5	121.5	151.5	219.5	195.5	227	262	232
9	Mechanical efficiency in per cent. $\eta_m = \frac{N_e}{N_i}$	77.5	78.5	64.7	67.0	78.3	80.0	78.2	65.8	64.0	76.2	76.4	69.5	76.3
10	Thermal efficiency, based on I.H.P., in per cent. ... ... η^*	40.5	39.0	44.2	43.0	41.2	39.3	41.2	41.3	44.2	39.7	38.1	42.3	38.6
11	Commercial efficiency, based on B.H.P., in per cent. ... ... η_c *	31.4	30.6	28.5	28.8	32.1	31.3	32.2	27.2	28.3	30.2	29.1	29.4	29.5
	Compressor	—	—	—	—	—	—	—	—	—	—	—	—	—
12	Low pressure ... ... atm.	1.8	1.8	2.3	2.3	1.8	2	2	2	2	1.6	1.6	1.9	2
13	Intermediate pressure ... ... atm.	7	7	9	9	8	8.5	9	9	8	7	7	7.5	7.5
14	High pressure... ... ... atm.	60	60	60	60	55	60	55	55	60	60	60	65	70
	Scavenging pump	—	—	—	—	—	—	—	—	—	—	—	—	—
15	Temperature of room ... ... T° C.	16	16	16	16	18	18	18	18	17	16	16	15	16
16	Temperature of suction air ... ... t_s° C.	12	12.5	13	13	15	14	14	15	13	13	12	9	10
17	Temperature of scavenging air ... t_{sc}° C.	38	39	40	38	37	37	37	36	43	43	43	44	45
18	Scavenging air pressure ... ... atm. abs.	1.12	1.12	1.12	1.11	1.11	1.11	1.10	1.10	1.14	1.14	1.14	1.17	1.17
	Fuel consumption	—	—	—	—	—	—	—	—	—	—	—	—	—
19	Total in kg./hour ... ... q_t	120.3	140.3	74.0	60.8	98.6	116.4	87.6	68.0	86.5	130.2	159	128.2	159.4
20	Per B.H.P. hour in grammes ... ... g_e	201	206	222	220	197.5	201.5	196.3	233	223	209.5	217	214	214.5
21	Per I.H.P. hour in grammes ... ... g_i	156	162	143	147	154	161	154	153	143	159	166	149	164
	Cooling water	—	—	—	—	—	—	—	—	—	—	—	—	—
22	Temperature of inlet water ... ... t_i° C.	9	9	9	9	9	9	9	9	9	9	9	9	9
23	Temperature of outlet cylinder water t_c° C.	37	40	30	26	39	40	49	38	29	38	41	29	33
24	Temperature of outlet piston water ... t_p° C.	37	42	31	30	35	36	37	33	28	33	38	31	40
25	Water consumption, litre/hour (*a*), cyl. Q_c	9900	10,302	10,500	8950	8950	8800	7650	7400	10,000	9900	11,200	12,800	12,800
26	Water consumption, litre/hour (*b*), pistons Q_p	3500	3750	3850	3280	3280	3220	2780	2680	4150	4100	4100	4650	4600
27	Water consumption, litre/B.H.P. hour (*a*), cylinder ... ... q_c	16	15.5	32	32	18	15.2	17	25	25.6	16	15.3	21.4	17.3
28	Water consumption, litre/B.H.P. hour (*b*), pistons ... ... q_p	5.9	5.6	11.7	11.7	6.5	5.6	6.2	9.2	10.6	6.5	5.6	7.7	6.2
	Exhaust gases...	—	—	—	—	—	—	—	—	—	—	—	—	—
29	Temperature of exhaust gases ... T_{ex}° C.	278	330	180	160	250	289	232	175	202	295	358	273	336
30	Gas analysis in per cent. ... ... CO_2	4.5	5.3	3.5	2.8	4.6	5.0	4.0	3.5	3.7	4.6	5.5	4.0	5.0
31	Gas analysis in per cent. ... ... O_2	14.5	13.1	15.9	16.7	14.2	13.4	15.1	16.1	16.1	14.4	12.7	14.5	13.6
32	$1 - \frac{79}{21}\frac{O_2}{N} = \eta_a$	3.05	2.53	3.9	4.9	2.92	2.62	3.33	4.05	4.05	3.0	2.42	3.0	2.7
33	Barometric height ... ... mm.	750	750	750	750	750	750	750	750	750	750	750	751	751

* Lower calorific value of fuel H_u = 10,000 cal/kg.

gauges. The water consumption was measured by Siemens' water-meters.

The results of trials are all grouped in the accompanying table and the diagrams, Figs. 8 to 11, on page 611, showing different curves. From diagram Fig. 8 it can be seen that the actually chosen mean effective pressure, $p_e = 4.8$ kg./cm.² can be reckoned as normal for the engine in question, as at this pressure the fuel consumption is best, whatever be the revolutions per minute. The fuel consumption at full load and normal speed is only 201 grammes per brake-horse-power hour and reaches a value of 196 grammes per brake-horse-power at 150 r.p.m.

The engine was guaranteed to give a fuel consumption of 220 grammes per brake-horse-power hour and not to exceed 245 grammes per brake-horse-power hour at full load and normal speed. With the rise of revolutions per minute at constant load (p_e = const.) the fuel consumption increases slowly, only by 10 grammes per brake-horse-power hour per 100 r.p.m., or not more than by 5 per cent.

At constant speed (diagram Fig. 9), say 200 r.p.m., and different loads the fuel consumption is lowest at full load, at half load it does not increase more than by 20 grammes per brake-horse-power hour, or 10 per cent. The fuel consumption per indicated-horse-power hour at constant load (p_e = const.) increases slowly with the revolutions, giving an increase of about 3 per cent. per 100 r.p.m. (diagram Fig. 10). The fuel used in the trial was Russian raw naphtha, sp. gr. 0.855 at 15 deg. C., lower calorific value, H = 10000 cal./kg., supplied by Messrs. Nobel Bros. Naphtha Production Co. The mechanical efficiency (diagram Fig. 11) at constant revolutions per minute and different loads (p_e = variable) varies from 64 per cent. to 80 per cent. (the last-named value at 150 r.p.m.).

The full load $N_m = 77.5$ per cent. At this load the scavenging pump takes 4.8 per cent of indicated power, the compressor 5.7 per cent., the remaining 12 per cent. being lost in friction, &c.

The thermal and commercial efficiencies (diagram Fig. 11) depend upon the loads and not upon the revolutions per minute (at least within the limits of 150 r.p.m. to 250 r.p.m.). With the increase of load the thermal efficiency is lowered, whereas the commercial efficiency rises, owing to a rapid increase in mechanical efficiency. The limiting values for thermal efficiency are 38 per cent. and 44 per cent., or a difference of 6 per cent., and for commercial efficiency 28 per cent. to 32 per cent., or a difference of 4 per cent. The mechanical efficiency at constant load (p_e = const.) (diagram Fig. 12) is nearly constant at different speeds. For a difference of 100 r.p.m. N_m changes by 2 per cent. at $p_e = 5.1$ kg./cm.

The temperature of the exhaust gases (diagram Fig. 13), as can be seen from curve for $p_e = 5$ kg./cm., increases from 235 deg. C. to 335 deg. C., or by 44 per cent. for an increase of 100 r.p.m. The maximum exhaust temperature is 358 deg. C. at 220 r.p.m. and 15 per cent. overload. Cylinder oil consumption did not exceed 3 grammes per brake-horse-power hour at full load. This consumption is higher than it ought to be generally, as the engine, being new, was amply lubricated during the trials.

In a two-stroke Diesel engine any reduction of power absorbed by the scavenging pump results in an increase of brake horse-power for the same indicated horse-power, thus increasing the mechanical efficiency and reducing the fuel consumption per brake-horse-power hour. In the case of the engine in question the scavenging arrangement allowed for a very low scavenging pressure being held, still providing a good scavenging of cylinders, thus reducing the size and power of pump. Owing to the low scavenging pressure the temperature of the scavenging air entering the receiver was not high and the fuel consumption very low, and complete combustion was obtained, as could be seen by the clean exhaust gases emanating from the silencer.

The chief particulars of the motor-ship Imperatritza Alexandra are as follow :—

Length between perpendiculars ...	243 ft.
Breadth	34 ft.
Draught, loaded	10 ft.
Depth	16 ft.
Displacement, loaded	1,700 tons
Cargo capacity	500 tons
Speed	12.5 knots.
Total engine power	1,200 b.h.p. with twin screws.
Number of passengers—I class...	24
" " II class...	53
" " III class...	60
" " deck...	166
" " steerage...	711
Total	1,014

ALQUIST GEARING FOR SHIP PROPULSION.*

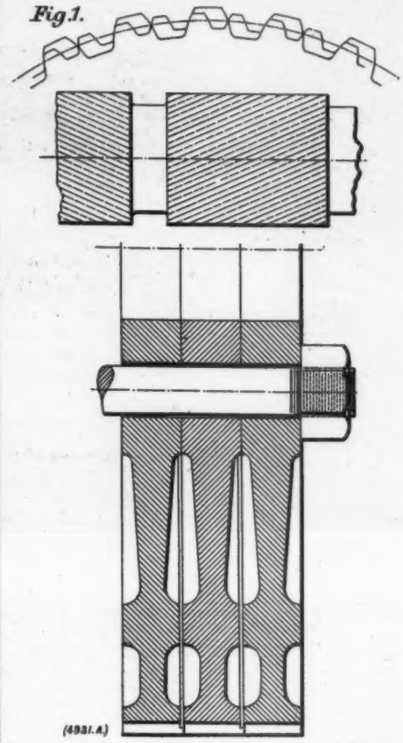
By W. L. R. EMMET, Member of Council.

THE designs described in this paper are based upon the inventions of Mr. Karl Alquist. Mr. Alquist is an accomplished engineer and was formerly connected with the turbine department of the English branch of the General Electric Company, the British Thomson-Houston Company. His gear inventions were first brought to the attention of the writer early in the year 1911. For some time previous Mr. Alquist had endeavoured to arouse interest in his methods in England and on the Continent, but had accomplished nothing. At that time the General Electric Company had not begun the commercial manufacture of high-speed spiral gears, but had for some time been conducting experiments to determine the limits of speed, pressure, &c., which were practicable with such gearing. The importance of high-speed gearing in connection with turbine and electrical applications is obvious and we were working with a view to development of the best standards.

Certain features of Mr. Alquist's proposals appealed strongly to the writer, and arrangements were made with Mr. Alquist to come to America and assist in experimental developments along the line of his inventions.

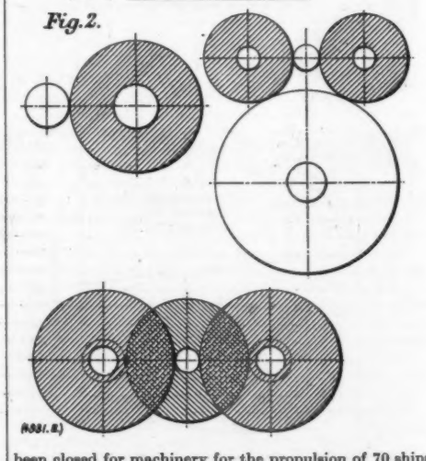
The result of this undertaking has been that many sets of gearing have been built and experimented with exhaustively under a variety of conditions, and by these experiments certain standards of practicability have been established and extensive commercial developments have been undertaken. Gearing of this character has been applied to about 72 sets where steam turbines drive electric generators of various types. Contracts have

Fig. 1.



(4931.A.)

Fig. 2.



(4931.B.)

been closed for machinery for the propulsion of 70 ships aggregating 215,200 h.p. Some of these electric generating sets have been in service 1½ years, and about seven of the ship sets are in service, some of them having made many long voyages. Among these are high-pressure cruising units for the battleship Nevada, which have been in service for some time and shown very fine results. Among the ship equipments not yet completed are included the propelling machinery for Destroyer No. 69, built at Mare Island, and new propelling machinery for the scout cruiser Salem. In all of this practical experience no case of trouble with gearing has developed and no appreciable deterioration of gears has been observed.

One of the important reasons for adopting this type of gearing was that its design tended to afford a distribution of strains and means by which excessive strains would not be imposed upon any part through slight imperfections, distortions, or inaccuracies. The uniform success which has been accomplished with an entirely new product shows that this expectation has been amply justified. Some of the gears which have been used

* Paper read before the American Society of Naval Architects and Marine Engineers, at New York, November, 1916.

ALQUIST GEARING FOR STEAM TURBINES.

Fig. 3.

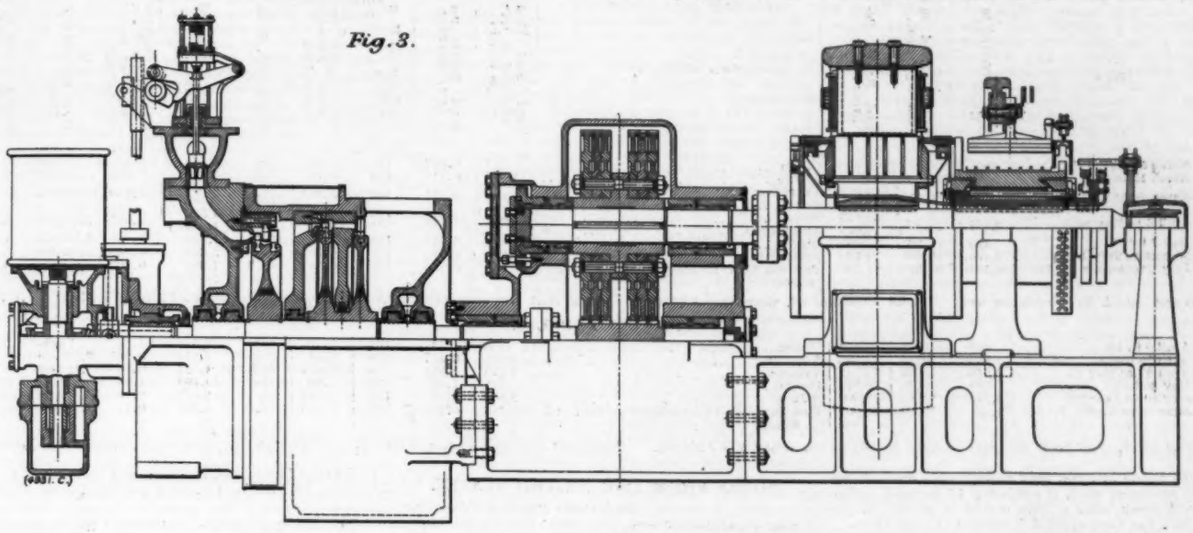


Fig. 4.

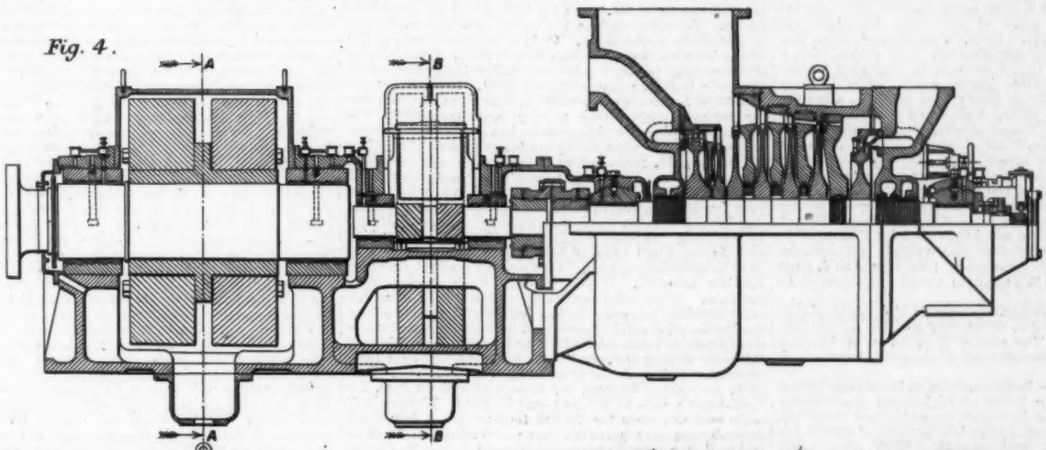
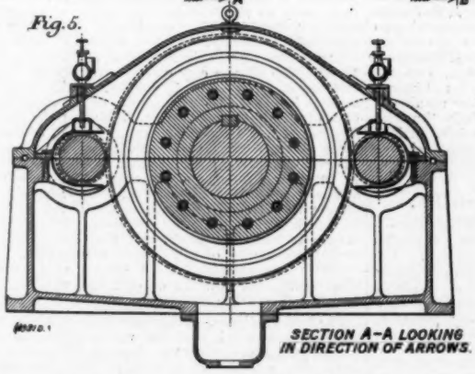
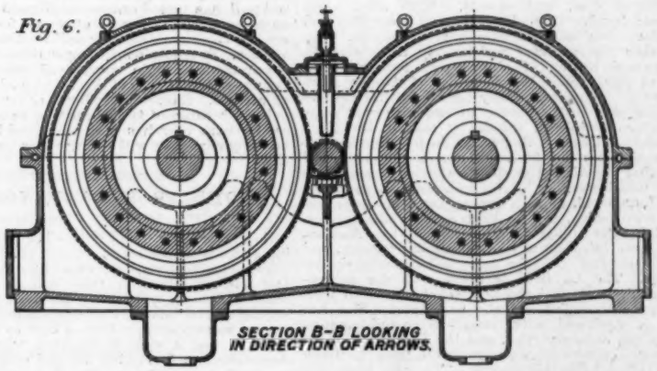


Fig. 5.



SECTION A–A LOOKING IN DIRECTION OF ARROWS.

Fig. 6.



SECTION B–B LOOKING IN DIRECTION OF ARROWS.

have been very imperfect, both in the matter of material and workmanship, and have been used under extremely trying conditions. That they have not failed has afforded the strongest evidence of the general reliability of the method.

The character of construction used in this gearing is shown by one of the drawings (Fig. 1, page 612). The gear is built up of a number of plates machined to a form which gives them the desired degree of lateral flexibility. These plates are put together, engaging solidly at the hub, and also engaging on a narrow edge at the periphery. When so built together they form a solid cylinder which can be spirally cut in the ordinary manner. After cutting, the edge engagements are relieved with a small dividing tool, so that each disc operates independently and is free to deflect laterally under the side pressure which results from its diagonal engagement with the pinion. The parts are so proportioned that this lateral deflection can at no time involve fibre strains which could possibly cause destructive fatigue. A very small amount of this lateral deflection is sufficient to afford the desired distribution of load, and this amount can easily be given without approaching dangerous periodic strains.

To appreciate the value of this flexibility and load distribution, various peculiarities of solid and spiral gearing must be considered. In the first place, where gears are inflexible there must always be a tendency to increase strain at the loaded end of the pinion through torsional deflection of the pinion. There is also a tendency to inequality of strain on different parts of the surface through the lateral deflection of the pinion under load. These inequalities can be partially compensated by elevating the bearings or evening the pressure on the bearings, but this compensation can only be partial because the correction applies only to the two ends and not to the middle. Furthermore, the momentary and periodic strains on different points of solid spiral gearing may be seriously affected by vibrations of supporting structures, irregularities of machine work or gear cutting, and other causes. If for any reason such conditions cause any tooth or part of a tooth to receive periodically excessive strains, fatigue may result and a broken tooth may destroy the whole gear. To obviate the possibility of breakage under such conditions it is often desirable in solid gearing to use relatively large teeth in order that these possible irregular strains on teeth or parts of teeth will not involve danger of breakage. For other reasons, however, the use of large teeth is distinctly undesirable in spiral gearing. Spiral gears tend to engage by point contacts at or near the pitch line, and the ability of these point contacts to bear pressure without fatigue of the surface metal is governed largely by the flatness of the surfaces engaging rather than by the size of the teeth carrying these surfaces. The flatness of the surface is a function of the pinion diameter and not of the pitch. If we double the number of teeth in a spiral gear we have twice the number of driving points in action, and the flatness of all of these points is the same in both cases if the pitch diameters are the same. These matters are illustrated in the sketches in Fig. 1, page 612.

With gearing of the Alquist type we can use very small teeth without any danger of incurring excessive strains on individual teeth, which might involve risk of the development of fatigue cracks. In this connection it

TABLE I.—SHOWING PERFORMANCES OF THE S.S. "LA BREA" AND S.S. "LOS ANGELES."

S.S. "LA BREA."

Voyage.	Date.	Total Distance in Knots.	Average Speed in Knots per Hour.	Total Barrels Delivered.	Name of Port.	Total Fuel Used Steaming on Voyage, in Barrels.	Barrels per Knot, Steaming.	Total Barrels Used in Port.	Total Barrels per Knot Steaming and in Port.	Time in Port, Hours.	Barrels Discharged per Hour.	Cost at 80 Cents per Barrel per Knot, Steaming and in Port (Fuel).	Shaft Horse-Power-Hours.	Pounds of Oil per Shaft Horse-Power.
												Dols.		
1	March 9 to 15, 1916 ..	650	9.5	62,578	Oleum	574	0.883	142	1.10	36½	1,714	0.88	116,000	1.67
2	March 15 to 26	2,037	11.33	73,600	Seattle	1,459	0.716	152	0.79	37¼	1,962	0.632	505,000	0.941
3	March 26 to April 6 ..	2,108	11.01	64,676	Vancouver	1,584	0.751	155	0.824	26	2,487	0.659	530,000	1.01
				8,642	Seattle					13½	640			
4	April 8 to May 16 ..	9,254.5	10.97	52,109	Taltal	6,896	0.745	117	0.757	33¾	1 544	0.605	2,330,000	1.00
				19,045	Antofagasta					15¼	1,228			
5	May 7 to 23	450	11.20	77,292	Oleum	321	0.713	134	1.01	39	1,980	0.808	1,180,000	0.911
6	May 24 to July 1	9,196.5	10.65	71,824	Antofagasta	6,900	0.75	109	0.762	25	2,660	0.609	2,200,000	1.06
7	July 1 to August 9, 1916	9,184	10.39	71,791	Port San Luis to Antofagasta, Chile, and return.	6,875	0.748	107	0.76	42.3	1,697	0.609	2,230,000	1.04

Average speed, 10.7 knots per hour. Total pounds of oil, steaming = 8,270,000. Total shaft horse-power-hours, 8,029,000. Pounds of oil per shaft horse-power-hour = 1.03.

S.S. "LOS ANGELES."

1	April 9 to 15	423	9.4	67,674	Oleum	556	1.31	164	1.70	64½	1,099	1.36	74,600	2.48
2	April 16 to 25	1,845	10.13	74,739	Vancouver	1,656	0.897	218	1.01	33¾	2,214	0.808	3,940,000	1.41
3	April 27 to May 25 ..	6,540	10.22	73,734	Panama	5,579	0.851	169	0.877	46¼	1,577	0.701	1,420,000	1.315
4	May 26 to 29	220	9.1	72,372	Oleum	221	1.00	123	1.56	41	1,770	1.24	39,000	1.88
5	May 30 to June 27 ..	6,348	10.6	72,538	Balboa	5,462	0.86	159	0.885	35	2,072	0.708	1,460,000	1.255
6	June 29 to August 7, 1916	9,151	10.24	71,007	Port San Luis to Antofagasta, Chile, and return.	8,293	0.906	186	0.926	56.3	1,261	0.74	2,130,000	1.31

Average speed, 10.27 knots per hour. Total pounds of oil, steaming = 7,310,000. Total shaft horse-power-hours, 5,538,000. Pounds of oil per shaft horse-power-hour = 1.320.

should be borne in mind that experiments have shown that the strongest steel, if subjected to periodic deflections, will break after a fibre strain of 20,000 lb. per square inch has been applied 1,000,000 or more times.

In the work which is now being done by the General Electric Company, gears of the type described are applied in three ways. First, a single reduction has been accomplished by engaging one solid pinion with a flexible gear of this type; second, by engaging a solid pinion with two flexible idlers, which idlers in turn engage with a solid large gear; and third, in a double reduction where a solid, high-speed pinion engages flexible gears on two countershafts, these countershafts carrying solid pinions, both of which engage a flexible gear on the same low-speed shaft. In these two latter applications the flexibility of the gears serves to equalise the loads between all of the driving points, and the use of a plurality of driving points on the large gear reduces the length of face necessary on that gear. These different methods of application are illustrated by diagrams in Fig. 2, page 612, and are also shown by the photographs and drawings of actual machines (see Figs. 3 to 6, page 613, and Figs. 7 and 8, page 616) which are attached to this paper.

In both of these cases where a single high-speed pinion drives two flexible gears, other very positive advantages are accomplished. The pinion is relieved of bending strains, and pressure on the high-speed bearings is avoided.

Experiments have been made in Schenectady which carefully analyse the losses of high-speed gears under various conditions of load and pressure, and these experiments have indicated that low peripheral speeds are more efficient than high speeds. With solid gears low speeds involve difficulties because they diminish pinion diameters and increase pinion lengths, thus complicating the troubles which may arise through deflection and torsion of pinions and pressure upon pinion bearings. Since the flexibility of Alquist gears enables us to compensate easily for all possible degrees of torsional yield in the pinion, we can with such gears safely reduce peripheral speeds by making the gears longer and of smaller diameter. Such reductions of diameter diminish weight and improve efficiency, and the fact that the Alquist method makes such reductions possible constitutes one of its important advantages.

Table I, annexed, shows a comparison of performances for two sister ships, the La Brea and the Los Angeles, operated by the Union Oil Company of Los Angeles. Both of these ships are new, carry similar cargoes, and burn the same fuel oil in the same boilers under similar conditions. The La Brea is fitted with our geared-turbine equipment, and the Los Angeles is fitted with triple-expansion engines of the best type. The Los Angeles is equipped with steam-driven oil-handling pumps of the ordinary type, and the La Brea is fitted with a new arrangement of pumps driven from the upper deck by General Electric motors. The table illustrates the superiority of the oil-handling machinery as well as that which propels the ships. The horse-power hours given in this table are calculated from the propeller and hull data given by the naval architect of the Union Iron Works who built the ships, and based upon model tank experiments which were made in Washington. The models of the ships are identical, the La Brea propeller operating at 90 r.p.m. and that of the Los Angeles at 65 r.p.m.

The seventh voyage of the La Brea and the sixth voyage of the Los Angeles were made over the same course and at nearly the same time. The relation of fuel economy of these two voyages almost exactly corresponds to that shown by the average of all the voyages and tends to verify the accuracy of the whole comparison.

American Forests.—The national forests of the United States yielded the Republic a revenue of 2,481,469 dols. in 1915, as compared with 2,437,710 dols. in 1914, 2,467,590 dols. in 1913, 2,157,356 dols. in 1912, 2,026,906 dols. in 1911, and 2,090,148 dols. in 1910.

NOTES FROM THE UNITED STATES.

Philadelphia, November 29.

The general steel situation continues acute. Prices are soaring upwards, with no indications of maximum limits. To what extent the mills are oversold cannot be definitely determined. Only a moderate proportion of the business presented can be accepted. Shipbuilding is attracting perhaps more attention than any other domestic industry depending on steel. Several neutral countries have very recently appeared in the market for tonnage aggregating a very large quantity. The demand for plate for this purpose has assumed very large proportions, and what are called fancy or premium prices are being paid, some orders being booked at 120 dols. a ton. Norway is a very heavy buyer for plates, and domestic shipbuilding requirements have within the vast few days crowded in at a surprising rate. Export inquiries are very urgent. Recent orders foot up 50,000 tons. Sweden requires 20,000 tons foundry iron and Japan 6,000 tons of low phosphorus. Basic pig-iron is especially active. This week's quotations show another advance. Heavy buying of all grades is in progress. With coke advancing and a labour shortage still another advance seems imminent. An absolute famine in pig-iron is threatened before urgent requirements can be taken care of. Car builders are taking all the orders they can, and last week 10,000 cars were ordered. This calls for over 130,000 tons of steel. Rail mills are asking 38 dols. for Bessemer and 40 dols. for open-hearth rails to be delivered in 1918. Western rail mills booked orders for 75,000 tons within a few days. Open-hearth steel sheets have again moved up. One eastern rail mill has added orders for 200,000 tons. Railroads have been large buyers of steel for structural purposes; their requirements will continue to agitate the market. It transpires to-day that additional European requirements are in process of submission, but the volume and character of this latest business is not known at present. Railroad earnings are far below maximum volume because of the scarcity of cars. Lake Superior ore for next year has been advanced 1.50 dols. Bridge building next year will absorb much more material than this.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

South Yorkshire Coal Trade.—The difficulty of obtaining supplies continues to occupy chief attention. The position has become accentuated by recent developments, and has steadily gone from bad to worse. Railway companies seem unequal to the task of maintaining a regular service between collieries and depôts. Ordinarily, empty wagons occupy from a day to two days on the journey, but a case is reported where wagons were despatched on November 30, and only arrived at their destination early this week. This is a typical example of what is taking place generally. It has a doubly bad effect. Not only are depôts denied adequate supplies, but pits are disorganised. Days are lost through the want of wagons, and as the situation affects different pits in varying degrees, half or quarter-time is only worked. This applies not only to South Yorkshire coalfields, but to the Nottinghamshire and Derbyshire pits as well. In some cases the railway deadlock holds up three or four weeks' supplies. The general fall of snow has added to the gravity of the position, but there are interested parties optimistic enough to declare that once the Christmas holidays are passed a steady improvement may be expected. All manufacturing fuels are very short supplies, and preference is given to munition works, blast-furnaces, railways, &c. House coal is likewise a tight market. Quotations:—Best branch hand-picked, 20s. 6d. to 21s. 6d.; Barnsley best Silkstone, 18s. 6d. to 19s. 6d.; Derbyshire best brights, 18s. 6d. to 19s. 6d.; Derbyshire house, 17s. to 18s.; best large nuts, 16s. 6d. to 17s. 6d.; small nuts, 15s. 6d. to 16s. 6d.; Yorkshire hards, 16s. 6d. to 17s. 6d.; Derbyshire hards, 16s. to 17s.; best slacks, 12s. to 13s.; seconds, 10s. 6d. to 11s. 6d.; smalls, 7s. 6d. to 8s. 6d. per ton.

Iron and Steel.—The metal market has a steady tone, and, probably owing to the approach of the Christmas holidays, buying has fallen off to a considerable extent. Makers of Lincolnshire forge qualities continue to find a fairly consistent inquiry for all they can supply, but No. 3 foundry meets with little activity. Derbyshire firms report only a small amount of business. The hematite supplies are still increasing, though they are hardly yet as numerous as local consumers would like. Still there is no apparent shortage, and even the special brands are fairly evenly distributed between all customers. No section of the market has been steadier than that for acid billets, which have remained at the same fixed quotation over a period of nearly half a year. The demand, in the eyes of the producers, is sufficient to justify a rise in prices, but at the present these stand at 15l. for Bessemer, and 15l. 10s. for Siemens. Extra special grades are proportionately dearer. Hard basic billets are nominally fixed at 11l., but little, if any, business is done at that figure, and if the material is for any other than war work the cost is much higher. Rolling mills are constantly enlarging their plant and additional companies have been formed, but nevertheless considerable arrears have accumulated on work other than class "A" under the Ministry of Munitions certificate. There is ample evidence that the present rolling facilities will have to be greatly improved upon if they are to keep pace with the other developments in the steel trade. Electric smelting of steel for mechanical purposes is increasing in favour, but it is beyond dispute that many of the leading firms prefer the crucible cast-steel for cutting tools, regarding it as the best possible material obtainable. Electric smelting, however, fills a great want in quickly supplying the lower grades, and the decision of the city council to acquire new power stations at the cost of 1,500,000l. is welcomed. Cheap current is essential to the success of the electric process. One of the latest converts to electricity is the firm of Messrs. Arthur Balfour and Co., Limited, of the Dannemora Steel Works, who have given a contract for a 12-cwt. Greaves-Etchell furnace. This will be installed in the new Broughton-lane shop. The cutlery, silver, and electro-plate trades are still apprehensive of the danger threatening them under the Order in Council—to which we referred last week—confining the use of copper to munition work, and they are pressing for a speedy relaxation of the drastic regulations. Overseas business has arrived for all classes of cutting tools, files, saws, liner bars for ore-grinding machinery, high-speed, carbon and other steels.

Sheffield Holidays.—Wherever it is possible, and the nature of the work in hand will permit, the Sheffield engineering shops will close down on Thursday evening until the morning of December 27. This gives the prescribed extra two days to make up for the holidays sacrificed earlier in the year, and also the intervening Sunday. Altogether a substantial period of rest and recreation.

American Natural Gas.—The yield of natural gas in the United States shows at present no tendency to decline. In 1885 the production was valued at 4,837,200 dols.; in 1895 the corresponding total stood at 13,606,650 dols., and in 1905 at 41,562,855 dols. In the ten years ended with 1914, inclusive, the annual value showed more steadiness and, at the same time, it exhibited a gradual tendency to increase the yearly totals, coming out as follow:—

Year.	Value.	Year.	Value.
	Dols.		Dols.
1905	41,562,855	1910	70,756,158
1906	46,873,932	1911	74,621,534
1907	54,222,399	1912	84,563,957
1908	54,640,374	1913	87,846,677
1909	63,206,941	1914	94,113,524

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—All-round activity prevails in the local steel trade, and makers are being constantly pressed for delivery of the supplies required by the Home and the Allied Governments for war purposes—the demands of France and Italy being particularly heavy and insistent. Scarcely any other export business is being put through than this, and even with the output at its present high level it is questionable if it in any way meets the demand, while every available source of energy is diverted to naval and military work, sectional steel and steel for shell bars being most urgently called for. For all, the pressure for delivery is great, and daily becoming greater, and judging from things just now it looks as if very shortly nothing but war work would be considered. Meantime, prices are merely nominal, ship plates about 14*l.* per ton; boiler plates, 15*l.* 10*s.*; and angles, 14*l.* 7*s.* 6*d.*; while steel bars (Siemens) may be 17*l.* or 17*l.* 5*s.* per ton.

Malleable Iron Trade.—Malleable iron makers report excellent business and a steady flow of good orders in both the iron and the steel departments. Some little business is being done in export by the iron department, but all the steel produced is earmarked for Government use, directly or indirectly, many of the mills which were hitherto run on iron being now devoted wholly to the production of steel. Prices are much on the same level as last week, "Crown" bars still being quoted about 14*l.* 10*s.* to 14*l.* 15*s.* per ton.

Scotch Pig-Iron Trade.—In the Scotch pig-iron trade matters move briskly along, and everything points to a continued steadiness of price, even to certain advances, although nothing definite has yet been made public. Ordinary Government work still takes precedence of all other, and practically nothing else is passing, licences being too difficult to obtain. The demand for hematite is so well maintained that no surplus appears on the market, the local steel works absorbing the entire output, while there is a growing scarcity of No. 1 foundry iron and forge iron, but meantime the production of these grades is limited, all the activity being diverted to war work. Except when tied, prices remain firm, those for export notably so.

Clyde Shipbuilders and Prohibition.—At a largely attended meeting of Clyde and West of Scotland shipbuilders and marine engineers held in Glasgow on Saturday last, at the instigation of the Board of Trade, some considerable discussion took place as to the best means of accelerating the construction of merchant shipping and engines. For some time past employers have been strongly of opinion that this can only be done by the total prohibition of the sale of all alcoholic liquor throughout the United Kingdom, and on various occasions representations have been made to the Central Control (Liquor Traffic) Board, urging the plea that the drinking habits of many of the industrial workers have acted as a very serious handicap to the production of work required by Government for the successful prosecution of the war. On Saturday a further step was taken when, in the name of the meeting, a telegram, signed by Mr. Thos. Biggart, secretary of the Shipbuilders and Engineers Employers' Association, was despatched to the Prime Minister, calling upon him to take the steps necessary in the matter.

IRON AND STEEL-ETCHING REAGENTS.—Discussing the reagents used for etching iron and steel in metallographic analysis, especially for the investigation of the distribution of phosphorus in iron, P. Oberhoffer recommends, in *Stahl und Eisen*, pages 798-799, 1916, the following modification of Rosenhain's solution: 500 cub. cm. of distilled water, the same amount of ethyl alcohol, 50 cub. cm. of concentrated hydrochloric acid, 0.5 gramme of $SnCl_2$, 1 gramme of $CuCl_2$, 30 grammes of $FeCl_3$. This solution is said to render the corrosion more gradual and uniform.

THE GREEK FIRE.—In a recent communication to the Paris Académie, Professor C. Zenghelis, discussing the ancient and modern literature on the so-called Greek fire, expresses the opinion that it was a mixture of nitre and various combustible substances, sulphur, charcoal, resins, oils, &c., and really the forerunner of gunpowder. The first mention he ascribes to Theophanos, about 750 A.D., who recorded that Callinicus, of Heliopolis in Syria, used the fire in fighting the ships of the Arabians in 672, when Constantine IV. Pogonatos was emperor. Zenghelis does not mention that this emperor, by the aid of the fire, kept the Arabians off Constantinople when they besieged his capital in 672–678, nor does he refer to the popular belief according to which the Greek fire was known to Constantine the Great, the emperor of the first Council of Nicæa (325), and was supposed to have come from China. The interesting new point is that Callinicus is said to have discharged a burning mass, which continued to burn under water, from a tube mounted on the prow of his ship, and that one man was sufficient to attend to this tube. Thus Callinicus would be the inventor of both gunpowder and the cannon. That nitre was one of the constituents was suggested by Berthelot, among others, but this has been questioned because nitre was not supposed to have been known in the early Middle Ages, though Plinius had described the efflorescence of damp walls (calcium nitrate). The composition of the Greek fire, which probably varied in the course of time, was kept secret by the Greeks, but was not unknown later to the Saracens. Modern chemistry, of course, knows in phosphorus and some of its compounds, in metallic potassium, &c., bodies which will catch fire spontaneously when exposed to the air or in contact with water.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—There is the usual disinclination to operate shown by traders as Christmas approaches, but there is an all-round feeling of firmness, and though for the time being home consumers of Cleveland pig are not buying forward, the opinion prevails that the early part of 1917 will be characterised by much activity. A gratifying feature is the growing willingness on the part of home customers to take larger supplies of forge iron to mix with the better kinds. Forge quality is relatively quite plentiful, but the increasing demand is lowering makers' stocks somewhat. For home consumption No. 3 Cleveland pig, No. 4 foundry, and No. 4 forge all stand at 87*s.* 6*d.*, and No. 4 is quoted 91*s.*; whilst for shipment to our Allies No. 3 is 98*s.*; No. 4 foundry, 96*s.* 6*d.*; No. 4 forge, 95*s.* 6*d.*; and No. 1, 102*s.* 6*d.*; and for export to neutral countries No. 3 is 105*s.* and upward, and No. 1 is 110*s.* and upward. Further sales to Italy are understood to have been made in No. 3 at round about 98*s.*

Hematite Iron.—Very little that is new is ascertainable concerning the East Coast hematite branch of the iron trade. Prompt business is practically at a standstill, but good inquiries, both on home and foreign account, are reported for delivering over periods next year, and a moderate amount of forward business is passing. Values are well maintained. For home use, Nos. 1, 2 and 3 are 122*s.* 6*d.*; for delivery to France the price is 137*s.* 6*d.*; and for export to Italy the quotation is 142*s.* 6*d.*

Stocks and Shipments of Pig-Iron.—Makers' stocks of pig-iron, with the exception of Cleveland forge quality, are very low indeed. The quantity of Cleveland pig in the public warrant stores now stands at 4,088 tons, consisting of 4,052 tons of No. 3 quality, and 36 tons of other kinds of iron deliverable as standard. Since the beginning of the month the stock has been reduced by the withdrawal of 85 tons of No. 3. Shipments of pig-iron from the Tees, though not large, are up to expectation. So far this month they amount to 21,175 tons, as compared with 16,510 tons to the same date last month, and 29,450 tons for the corresponding part of December last year.

Output of Pig-Iron.—Production of pig-iron is being increased by the restarting of furnaces that have been idle for some time. At one works an additional furnace has been blown in to produce hematite, and another firm has transferred a hematite furnace on to the manufacture of Cleveland pig. The number of furnaces now in operation on the North-East Coast is 76, of which 32 are turning out Cleveland pig, 30 are producing hematite, and 14 are manufacturing special kinds of iron. Several more furnaces are expected to be in blast early next year.

Shortage of Trucks.—The annual grumble as to shortage of trucks, which usually occurs at this season, is heard once more. Some firms complain that the shortage is causing rather serious inconvenience by the delay in delivery of coke and pig-iron.

Foreign Ore.—Supplies of foreign ore are coming steadily to hand on a satisfactory scale.

Coke.—Demand for coke for local consumption is heavy, and some firms are pressing for immediate delivery. Maximum rates continue to rule. Average blast-furnace coke readily realises 28*s.* at the ovens, and the limitation price of 30*s.* 6*d.* at the ovens for qualities low in phosphorus is readily paid.

Manufactured Iron and Steel.—Producers of finished iron and steel are kept very busily employed, chiefly on Government work, but they report a very considerable and growing output of mercantile shipbuilding material. The following are among the principal quotations to home customers:—Common iron bars, 13*l.* 15*s.*; best bars 14*l.* 2*s.* 6*d.*; best best bars, 14*l.* 10*s.*; best best best bars, 14*l.* 17*s.* 6*d.*; iron ship plates, 13*l.* 10*s.* to 14*l.* 10*s.*; iron ship angles, 13*l.* 15*s.*; iron ship rivets, 17*l.* 10*s.* to 18*l.* 10*s.*; packing iron and steel (parallel), 12*l.*; packing iron and steel (tapered), 14*l.* 5*s.*; steel bars (no test), 14*l.* 10*s.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel ship rivets, 19*l.* to 20*l.*; steel boiler plates, 12*l.* 10*s.*; steel strips, 17*l.*; steel hoops, 17*l.* 10*s.*; steel joists, 11*l.* 2*s.* 6*d.*; and heavy sections of steel rails, 10*l.* 17*s.* 6*d.*

SPLIT-PHASE MAGNETS.—Split-phase magnets have been designed of late for the purpose of producing a quiet holding pull from alternating-current excitation. In the *Electrical World* of November 18, 1916, Mr. E. Hyman discusses the theory with respect to magnets of the following type. There are two cores, *e.g.*, two rectangular frames of the same material, the one inside the other; the primary winding embraces part of both the cores; the secondary is on part of the one core only. When the primary is excited, two different fluxes will be set up, neither sinusoidal and differing in phase. Such a magnet would not behave like an ordinary continuous-current magnet. An ordinary magnet has its maximum pull when in the holding position, and the pull diminishes rapidly as the armature is further removed from the poles. The split-phase magnet and starting pull is greater than the holding pull, and it would appear possible so to combine a direct-current and an alternating-current magnet, or two alternating-currents of opposite characteristics, that the pull should remain practically constant over the entire range from the opening to the closing of the jaws.

NOTES FROM THE SOUTH-WEST.

Cardiff.—The steam coal trade has been more settled of late. There being more tonnage and more railway wagons available than was the case a short time ago, deliveries have taken place more easily and an improved situation has set in, the pits working regularly. The best Admiralty large steam coal has remained nominal; secondary qualities have made about 27*s.* 6*d.* to 30*s.*, whilst best bunker smalls rule between 18*s.*, and 19*s.* Monmouthshire Black Veins have been quoted 27*s.* 6*d.* to 30*s.*; ordinary Western Valleys, 27*s.* 6*d.* to 30*s.*; Eastern Valleys, 25*s.* to 27*s.*; cargo smalls, 12*s.* to 17*s.* In bituminous coals best households have made 25*s.* 6*d.* to 26*s.* 6*d.* at the pit mouth; No. 3 Rhondda large, 26*s.* to 27*s.*; smalls, 20*s.* to 21*s.*; No. 2 Rhondda large, 25*s.* to 27*s.* and No. 2 smalls, 17*s.* to 18*s.* Patent fuel has been quoted 35*s.* to 37*s.*; special foundry coke has made 62*s.* 6*d.* to 65*s.*; good foundry coke, 57*s.* 6*d.* to 60*s.*, and furnace coke, 47*s.* 6*d.* to 52*s.* 6*d.*, these three quotations for coke being for export. The pit-wood prices were on the increase, at about 50*s.* ex ship.

Western Trade Matters.—The trade of Swansea last week amounted to a total of 66,032 tons, as against 67,863 tons during the preceding week, and 95,431 tons for the corresponding week of last year. The exports formed a total of 55,492 tons, in which coal entered for 41,294 tons, patent fuel for 8,110 tons, tinplates and general goods for 6,088 tons. The imports formed a total of 10,540 tons, and included timber and general goods.—There is great activity in the pit-timber trade.—Speaking last Monday at the monthly meeting of the Eastern Valley Miners' District, held at Pontypool, Mr. James Winstone stated that he had always approved the principle of fining for absenteeism. A large part of the responsibility for absenteeism, he added, rested upon colliery managers, who should be brought to account as well as the men. Ninety-five thousand Welsh workmen had joined the colours, and the total amount of avoidable absenteeism, he said, was 5 per cent., whilst the output of coal had increased by 240,000 tons for the last quarter as compared with the corresponding period in 1915.—It is reported that large tracts of land have been purchased between Newport and Cardiff for the putting down of works to be employed in a branch of the metal trades.—At a meeting of the Cynon Colliery Company, held at Cardiff on Monday, reference was made to the appointment of Lord Rhondda as President of the Local Government Board and the consequent severance of his connection as director of the company; a resolution was passed declaring a dividend of 7½ per cent., making 15 per cent. for the year.—The accounts of the Blaenavon Company, Limited, were stated, at the annual meeting last Tuesday, to be most satisfactory, compared with the figures for last year. The 15 per cent. advance in wages was stated to be unjust, especially for collieries situated like the Blaenau collieries, but this advance having been ordered by the Government, the company had to submit.

AMERICAN LOCOMOTIVE BUILDING.—The demand for locomotives in the United States continues active. The Southern Railroad Company contemplates buying 45 engines; the Chicago, Burlington and Quincy 30; the Union Pacific, 15; and the Duluth, Mesaba and Northern, 6. The American Locomotive Company will build 40 consolidation engines for the Italian State Railways, 10 Pacifics for the El Paso and South-Western Railroad, and 5 each for the Delaware, Lackawanna and Western, the Central Railroad of New Jersey, and the Western Pacific. The Louisville and Nashville is building 8 Mikados in its own shops, and will soon begin 8 more.

JAPAN.—Mr. Elbert H. Gary, president of the American Iron and Steel Institute, in speaking at a recent St. Louis meeting of that body, observed that the Japanese people had adopted and assimilated what they considered the best features of enlightened civilisation in different countries. They were highly intelligent, determined, adaptable, very industrious and, above everything else, superbly loyal to their Emperor and their nation. There were no internal strifes; on the contrary, there was a harmonious whole, and they presented to the outside world a united front. This was as it ought to be in every nation, as it gave a solidarity of power which was invincible. This was why Japan had taken a leading position among the nations of the world, contrasting in a striking manner with her position 60 years ago. Japan had, with Korea, Formosa, and other island territory recently developed, 259,671 sq. miles and a population of 72,000,000, as compared with 37,000,000 in 1872. Besides all this Japan was increasing in wealth, and in the early future she would probably be considered rich. Her financiers, her business men, and her statesmen stood high; they were far-seeing and conservative. When he was recently in Japan he was open and sincere, and as he was an American independent of any political obligation to consider questions of diplomacy, he received willing and attentive listeners. He believed that the leading and controlling men of Japan were anxious for a permanent continuance of the peaceable and friendly relations now existing between Japan and the United States. The most prominent national men in Japan were outspoken in their friendship for the United States and her citizens. They refer with increasing satisfaction to the large trade relations now existing, and they speak of Americans as friends and advisers. He thought their American best men should come into close contact with the people of Japan, China and the Philippines, as such a state of things would be beneficial to all.

ALQUIST GEARING FOR STEAM TURBINES.

(*For Description, see Page* 612.)

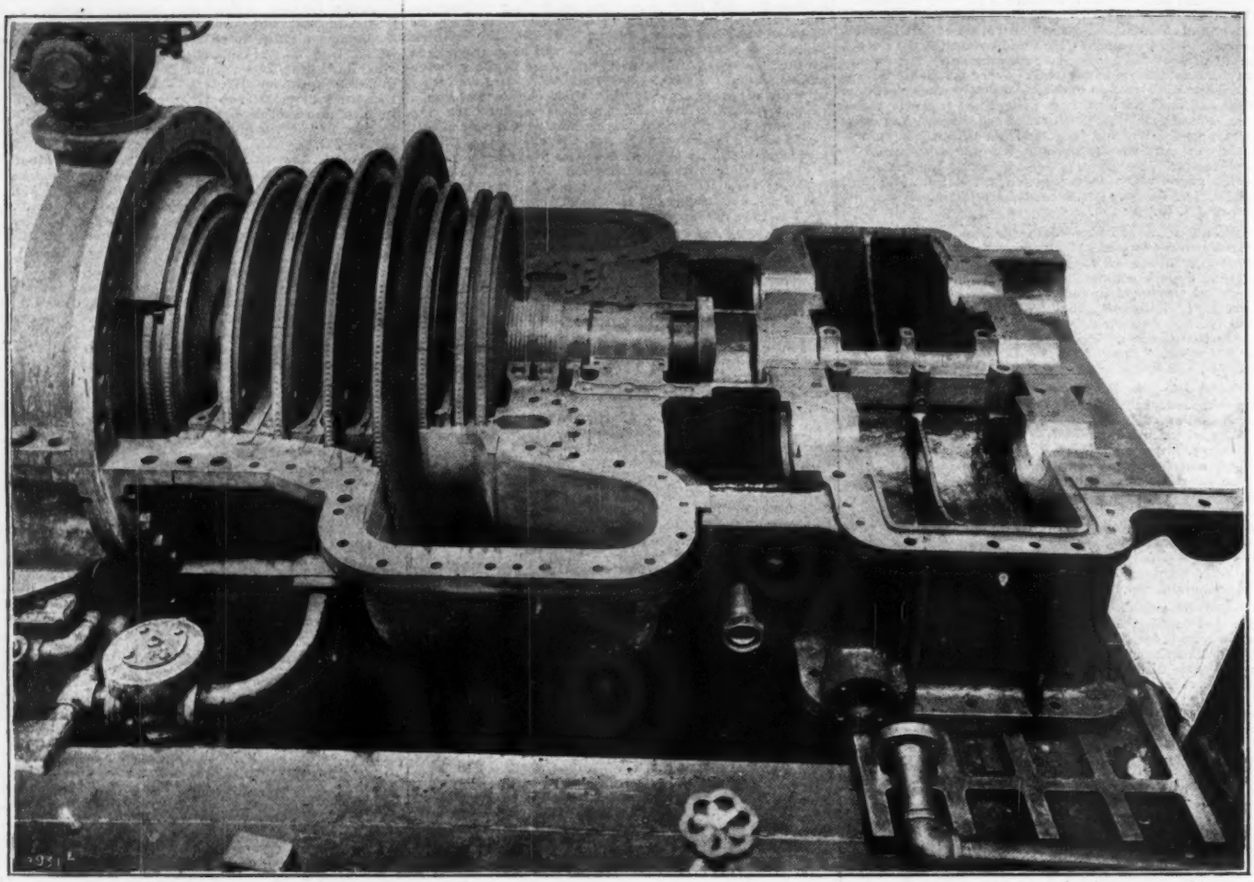


Fig. 7.

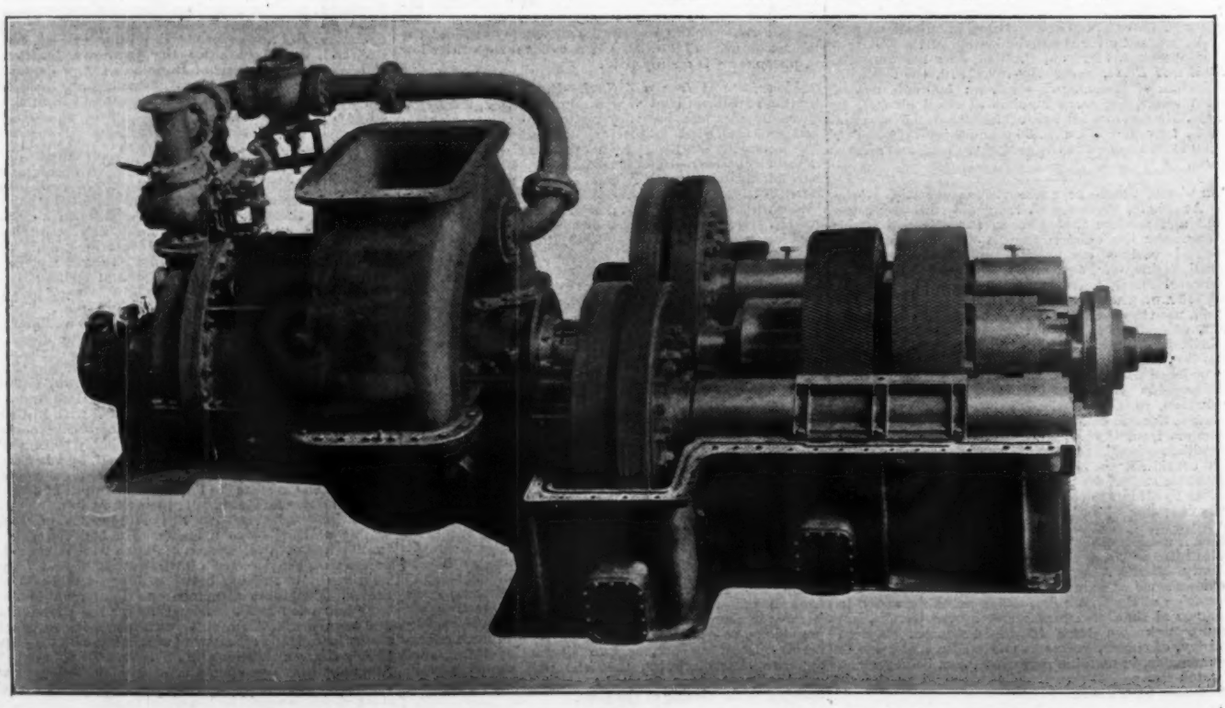


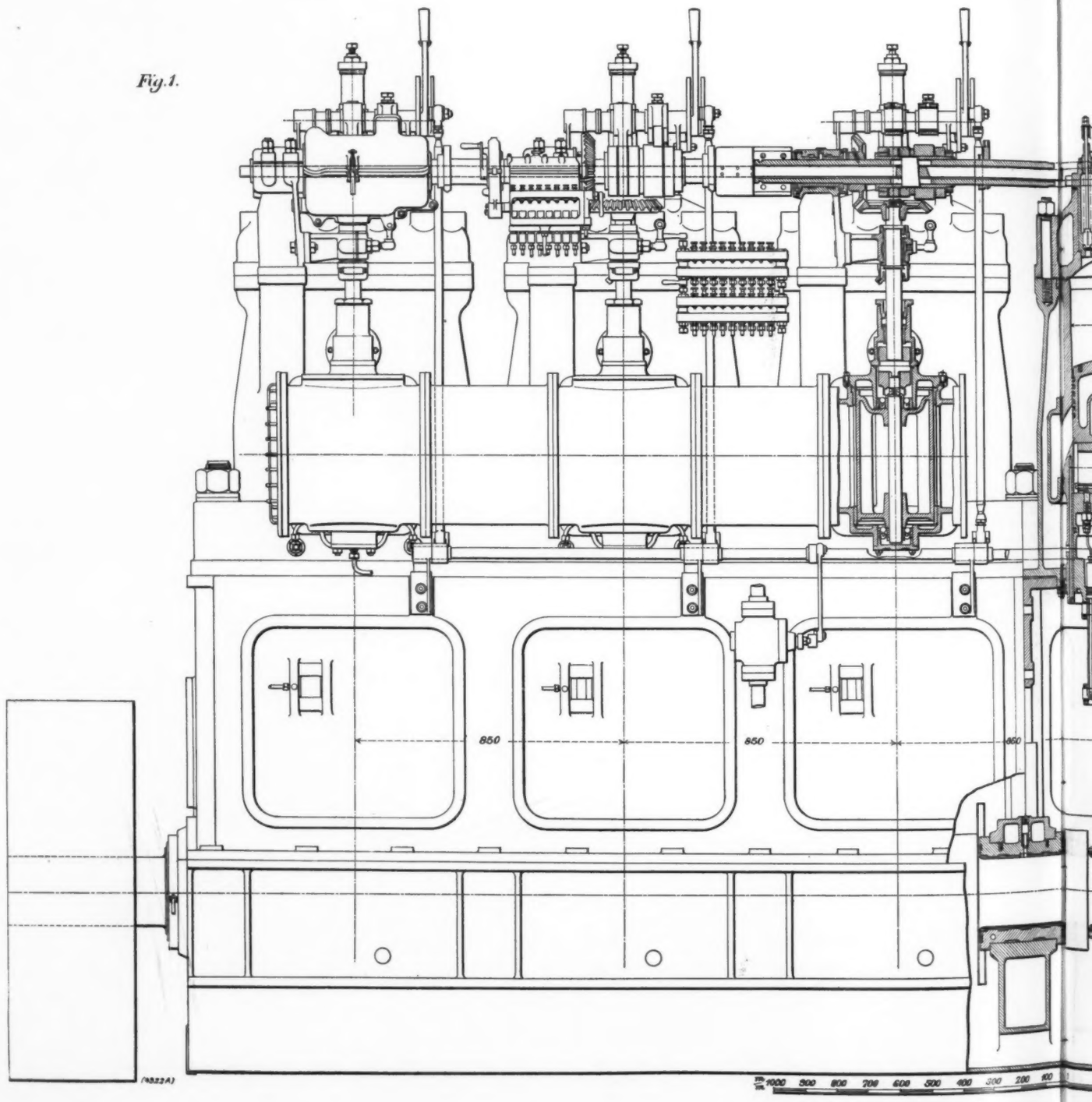
Fig. 8.

600-B.H.P. TWO-STROKE CYCLE DIRECT-REVERSIBLE DIESEL ENGINE FO

CONSTRUCTED BY THE LUDWIG NOBEL COMPANY

(For Description see Pag

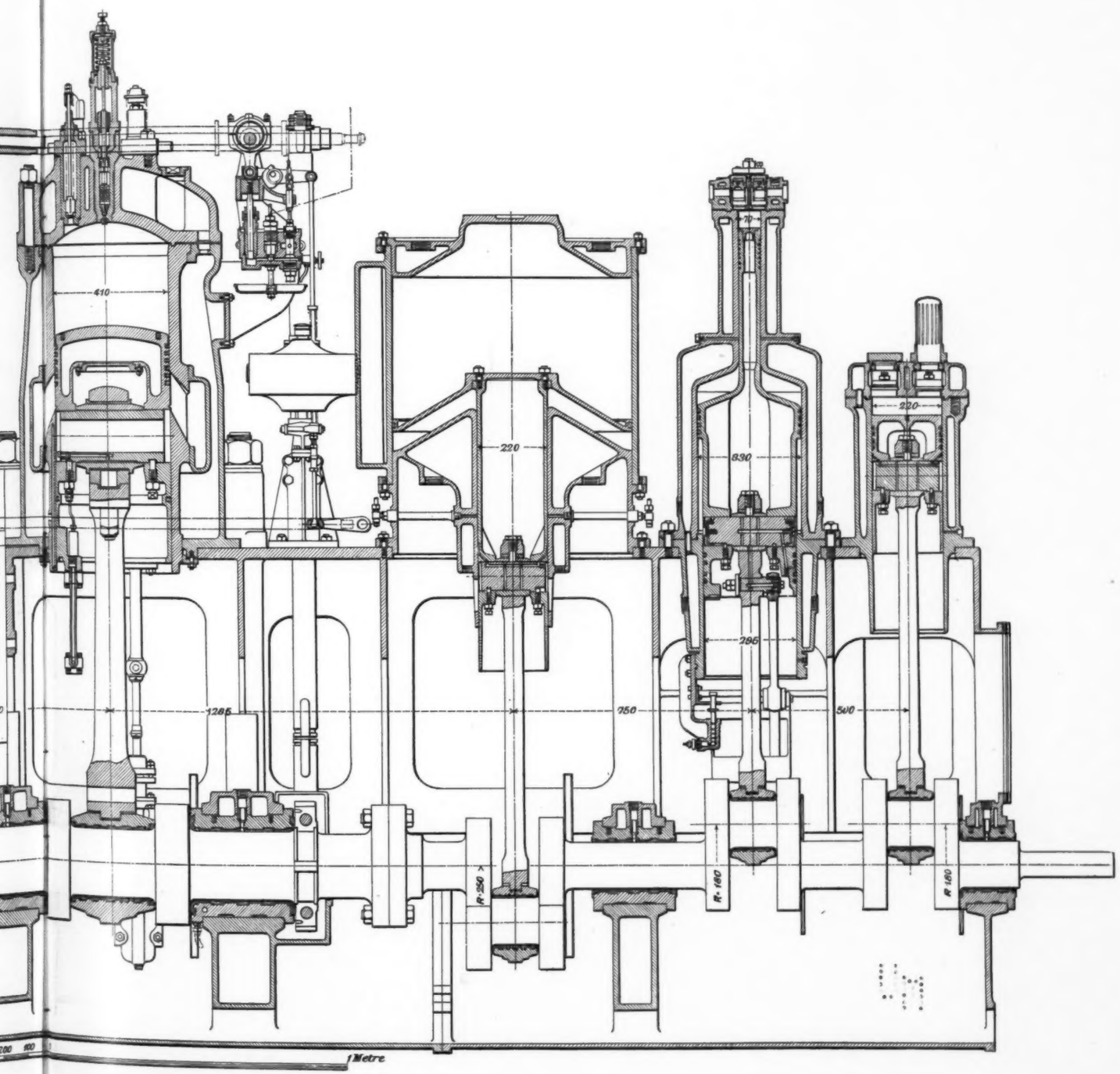
Fig. 1.



GINE FOR THE TWIN-SCREW MOTOR-SHIP "IMPERATRIZA ALEXANDRA."

BEL COMPANY, LIMITED, ENGINEERS, PETROGRAD.

scription see Page 608.)



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NOTICE OF MEETING.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Christmas Lectures:—"The Human Machine which All must Work," will be delivered by Professor Arthur Keith, M.D., F.R.C.S., LL.D., F.R.S. Thursday, December 28, "Living Engines;" Saturday, December 30, "Living Pictures."

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

ENGINEERING.

FRIDAY, DECEMBER 22, 1916.

MACHINE TOOLS AND FUTURE INDUSTRY.

IT is quite wrong to presume that the demand for munitions of war of all kinds has involved such an accession to the machine-tool equipment in this country that little will require to be done in this connection for a long time. This idea ought to be combated now and strongly. It is true that a large number of new factories have been built and that extensive additions have been made to existing works, principally to produce shells. Others, of course, are occupied in more general work; for instance, in the construction of guns and howitzers, with their mountings and carriages. Moreover, each shell requires a fuse, which for its manufacture involves a large number of machines suitable for repeat work. But, in any case, the great majority of the machine tools introduced within the last two years have been more or less of a special character, and, apart altogether from the question of their deterioration due to excessive use, it is important that manufacturing firms should carefully consider their applicability either to the standard peace work of the establishment or to that additional work which such firms intend to undertake at the close of the war.

A consideration of the question is necessary at the present time because the item, in the financial statement of all firms, regarding depreciation and obsolescence must be determined with great discretion. We are not of those who believe that munition firms are making fabulous profits. Their establishments are controlled, the workers are liberally paid for their output, and the Ministry of Munitions, assisted by the Treasury, are making certain that a preponderating proportion of any excess profit which may be made shall revert to the national purse. When this claim has been met by the proprietors of controlled firms they will act wisely if they reserve as large a proportion as possible of any remaining profit in excess of peace conditions to meet the claims of depreciation and obsolescence, with special regard to the future. The present condition of every tool ought to be carefully examined, but more important still is the determination of its adaptability for future manufacture.

When the demand was first made for an enormous augmentation in the manufacture of shells official pressure was brought to bear on firms capable of organising the manufacture of such munitions, to secure lathes or other machine tools wherever they could be got, and however they might have been made. The exigencies of the case justified the purchase of tools hastily made and without due regard to the severity of the work demanded from them. As a consequence many such tools are already, or must soon be, of no further use. When the machine-tool makers were able to meet the demands with tools of suitable design and adequate strength, a better type became available for shell manufacturers, but the rate of depreciation is enormously greater than under normal circumstances, first, because of the continuity of work, and, secondly, because of neglectful use due to the inexperience of unskilled or semi-skilled workers. In reckoning depreciation, it is not satisfactory to consider the time element alone. To-day machines are worked with relays of operators for 120 and even 130 hours per week, whereas in normal times 60 hours would be a high average. But, apart from this, there is the fact that continuity of work prevents periodical examination, and in the absence of this defects which would easily be remedied in the early stages develop into rapid and serious wear. Bearings constitute an example. Many of the shell manufacturers are consequently satisfied that only a small proportion of the lathes which have been continuously at work for the past two years can be relied upon for efficiency in general engineering in the future.

The rate of obsolescence, too, must be considered. This is a term which the accountant has been forced to take into consideration in industries where there is a possibility of such development either in process of manufacture or in types of machine tools as necessitates the building up of a financial reserve to enable employers at once to scrap otherwise suitable plant with the object of taking advantage of superior specially designed appliances, in order to achieve the highest efficiency. The practice of thus considering obsolescence in appraising the value of plants is not applied as extensively as it should be; but the question of the utilisation of machine tools for the future requires that this year all munition firms should specially consider carefully whether and to what extent it is possible to determine a rate of obsolescence, and such rate should be added to a more than usually high allowance for depreciation. This is amply justified by the limitations imposed on the future use of some of the machine tools, especially all those used for munition work. The output of shells is stupendous. The number of lathes purchased cannot by any stretch of imagination be regarded as other than greatly in excess of all of our possible peace requirements. These lathes are short in the bed and heavy in the headstock, since the large shells are short and of great weight. Thus greater power is required to drive them than would be necessary for lathes of the same height of centres and of normal proportions. No doubt some of the repeat machines required for fuse-making and other highly accurate work will be utilisable for peace work, but here, again, the excessive degree of accuracy required has involved a price for the machine tool which ordinary peace manufactures may not justify. Thus a high rate of obsolescence is as essential as where the tool may be inefficient.

What is required, therefore, of engineering manufacturers is at once to determine the policy to be adopted now in anticipation of peace manufactures, and to secure the support of the Ministry of Munitions, if not also of the Treasury, in preparing their financial reserve to meet the future conditions as regards machine tools. This is of vital importance, because the need immediately after peace is won will be to adapt our engineering establishments for mechanical manufacturing under the most efficient conditions. There is certainty of a great demand after the war, and an almost equal certainty that the rate of wages will continue, at all events for some time, at a high rate, probably at the present war rates. That contingency, at all events, has to be met, and it can only be met by the application of such machine tools as will achieve the maximum of output for the minimum of manual effort. If this is to be attained, every machine tool must be specially adapted for the particular operation for which it is intended. It would be a grave national disaster to assume that lathes for the turning, externally or internally, of shells can possibly ensure efficiency in operations where a special type of machine is required. It is owing to such makeshift methods that we have failed in the past to keep pace with our foreign competitors. To-day the conditions are most favourable for a change in our manufacturing methods. This is particularly so, because trade unionists in the past twelve months have realised not only the national advantage in increased volume of output due to every machine being utilised at its fullest capacity, but the benefit to the worker in securing high earnings per week under normal premium bonus rates or piece-work rates of remuneration. Never have earnings been so high, and although in the future the workers will not have the incentive of patriotism to exert themselves physically to maintain their high degree of output, we are satisfied that the past experience will encourage them to do

fuller justice to more efficient machine tools in the future than in the past.

It is consequently the duty of all machine-tool makers to prepare at once for this new development in this country by improving the design of their machines and organising their industry in order that there shall be standardisation in their manufacture, so that there shall be efficiency in the machine-tool maker's works and a reduction in the cost of producing machine tools. To be candid, it must be recognised that in many directions foreign manufacturers have shown initiative. This applies particularly to the American machine-tool makers, owing in large measure to the economic conditions justifying the fuller utilisation of modern machine tools in the States, because of high rates of wages and high cost of living. In the national interest we cannot afford to neglect any advantage which superiority in machine tools, whether in respect to the applicability to special function or to any other feature of design, will give us in the direction of making our works more efficient and our production more rapid and economical. The British maker of machine tools must, in competition, rely most largely on the superiority of his production, just as all engineering firms in the future must apply the same principle if they are to maintain their place in the foreign as well as the home markets.

THE RAILWAY WAGON PROBLEM.

Engineering and other firms are once more experiencing difficulties in obtaining an adequate supply of empty wagons, and there are indications that the railway wagon problem is again becoming acute. At this time of the year the demand for wagons is always great. This year the growing output of munitions of war and other Government traffic accentuates the demand. For the railway companies it has been stated that there is no shortage of wagons, but only of *empty* wagons. On this hypothesis the Board of Trade have called the attention of traders to the urgent importance of taking every step in their power to avoid delays to wagons in loading and unloading. It is pointed out that the saving of a day all round would effect a substantial addition to the rolling-stock. More recently the Board of Trade have been given powers, by an order in Council under the Defence of the Realm Act, to make orders "for enforcing the prompt loading or unloading of wagons, by making failure to load or unload in accordance with the order an offence." This raises the whole question of demurrage and suggests that wagons are now avoidably delayed. We do not think this would be admitted by engineering firms, more especially having regard to what the railways have done in recent years in enforcing payment of demurrage charges. In some instances it may be that wagons have been kept under load and practically used as warehouses; but the present scale of charges is calculated to deter traders from so doing. We may recall that, with the termination on June 30 last of an arrangement applicable to South Staffordshire and South Wales, the demurrage regulations were standardised for practically all railways in England and Wales. These provide for a free period of one day, exclusive of the day on which loading is begun, in the case of outwards traffic from stations, and two days, exclusive of the day of arrival, at stations, after which 1*s.* 6*d.* per wagon per day is charged. One day more is allowed in the case of private sidings and docks and higher charges are applicable to high-capacity and specially constructed wagons.

Traders are experiencing difficulties in obtaining an adequate labour force in the same manner as railway companies are. There is also the fact that railway delays due to the heavy and urgent demands for the conveyance of war material react on the arrangements for securing prompt discharge of wagons. Whether any material improvement would result from the enactment of more stringent regulations is problematical.

In our view the railway companies should extend the mutual user of wagons and in other ways devote their attention to the prevention of light or empty wagon mileage. At the present time there are three combinations of companies so far as ordinary open goods wagons are concerned. The Great Western, Lancashire and Yorkshire, London and North-Western, Midland, and North-Eastern companies are parties to an arrangement made in March last applicable to certain types of open deep-sided wagons. The Great Central, Great Eastern and Great Northern lines have a somewhat more comprehensive scheme, while the principal Scottish railways are parties to another. But no attempt has yet been made to co-ordinate the distribution and user of the whole of the rolling-stock of the country. We understand that consideration is now being given to this, but in our view it is a matter to which the Railway Executive Committee should have given attention months ago. The railways have been under Government control for two years and four months, yet many lines are still being operated in the old, individualistic way. We quite appreciate that the organisation for controlling the supply of wagons would need to be altered to suit the new conditions of working, but there should be no difficulty in devising a suitable system.

Associated with the question of railway-owned wagons is that of privately-owned wagons. A reliable estimate places the number of the latter now in use in this country at about 700,000. With minor exceptions the whole of this enormous total of wagons run empty in one direction. This fact has only to be stated to at once indicate the enormous amount of haulage capacity that is available for use provided a scheme can be devised for using it. Not only so, but each colliery company has its own wagons, and even individual small coal merchants own from a single vehicle upwards. These have to be shunted out, thereby entailing much shunting mileage in addition to empty train mileage. In view of this the Coal Mining Organisation Committee suggested—more than a year ago—that the Railway Executive Committee should prepare a scheme of wagon pooling suitable to the different districts; and that it should be submitted to the coalowners and others for their consideration in the national interest.

We are aware that the taking over by the Government of privately-owned wagons would not be generally acceptable. Indeed, in Engineering of March 31 last we set out at length the considerations for and against such a proposal. But in the present emergency national interests should alone count, and we believe that view would be accepted by all parties. In fact, following a conference between representatives of the Board of Trade and of private wagon owners in December last, the British Wagon Company intimated that, while strongly of opinion that a scheme for pooling wagons would be exceedingly difficult to form, they would be prepared to give the Board of Trade what assistance they could "in the national interests." A year has gone by and the wagon difficulty is again acute. Empty wagons are still being hauled all over the country and, so far as we are aware, no scheme of pooling or common user has yet been produced. Among other powers recently conferred on the Board of Trade, however, is the ability to make an order for taking possession of any private owner's wagons and to use those wagons in such manner as they think best in the interests of the country as a whole, on such conditions as to payment, use and otherwise as may be provided by the order. In view of these powers there is certainly no reason why further delay should take place in tackling a problem the solution of which offers the possibility of effecting great economies in railway operation while adding to the supply of rolling-stock to meet the requirements of traders.

UTILISATION OF THE DISCHARGE THROUGH GASES.

The study of the electric discharge through tubes filled with gases, rarefied or not, has so far been almost entirely of the nature of purely scientific research. Some recent experiments conducted by Professor F. Skaupy, of Berlin, however, open out further hope of technical utilisation. Skaupy observed that gas mixtures are separated into their constituents when the discharge passes through them, the one constituent collecting near the kathode, the other near the anode, and that it is possible to withdraw and to isolate those constituents. He further found that certain reactions and polymerisations take place in mixtures of vapours and gases exposed to the discharge, and he expresses the opinion that atmospheric nitrogen might be bound in this way by the glow discharge, instead of being oxidised by the arc discharge. His first communication, made to the Physikalische Gesellschaft ("Verhandlungen," April, 1916, page 230) and his subsequent communication presented to the Deutsche Chemische Gesellschaft ("Berichte," September, 1916, page 2,005) are little more than preliminary, and it will be a long step yet to technical application. But the investigations are certainly very suggestive.

Sending the continuous current discharge through a neon tube, containing 10 per cent. of argon, at a pressure of 5 mm., Skaupy noticed that the anode spectrum showed, after a few minutes, the very characteristic neon lines, the kathode spectrum the argon lines, while the glow of the middle portion of the tube (300 mm. long, 10 mm. wide) gave intermediate spectra. Mixtures of helium and argon behaved similarly, and it was found that the gas possessing the lower ionisation potential collected at the kathode. In mixtures of three gases, the gas characterised by the medium ionisation potential was concentrated in the middle portion of the tube. By feeding new mixture into the middle portion of long tubes and by withdrawing the gas from the neighbourhood of the electrodes—which were alkali metals in these experiments—Skaupy succeeded in separating and purifying the gases. The explanation suggested is that every gas has its own ionisation potential, the potentials of the rare (noble or inert) gases being higher than those of the common gases. The gas with lower potential will be ionised to a higher degree than the other, and at any particular spot the proportion of the positive ions of the former gas will be greater than would correspond to the original gas mixture; the positive ions will move towards the kathode. When vapours of mercury or salts are added to the inert gases, for the purpose, for instance, of increasing the luminosity of the glow discharge, the active ions will also travel towards the kathode therefore. Such additions, Skaupy points out, have sometimes been made to gas-glow tubes without any result, probably because the vapours had not been introduced at the anode; if introduced at the kathode they would remain there and would not make the glow of the discharge column more brilliant.

The use of inert gases as diluents of the vapours had the advantage that they allow of working with relatively high current intensities, and that they do not attack the electrodes. When a vapour is added to the gas the vapour may be decomposed by the discharge and the constituents be separately condensed or absorbed. Many vapours are slightly dissociated to start with, and the discharge will increase the dissociation and preferentially separate those dissociated particles. Thus when vapour of aluminum chloride is introduced into the middle of the tube, the ions of metallic aluminium travel towards the kathode and can be condensed there by enlarging the diameter of the tube, whilst the chlorine is bound by the anode. But the discharge may also favour combination or polymerisation by bringing the suitable constituents into contact with one another. Thus vapours of hydrocarbons led into the tube condense to coloured (generally yellow) polymerisation products on the cold walls of the tube; there is no carbonisation, as would result with the arc discharge or with incandescent electrodes. Skaupy has also obtained condensation products from mixtures of vapours of organic substances with free nitrogen. This novel way of binding atmospheric nitrogen will probably excite foremost attention at the present time. It will be understood that the inert gas is the carrier of the electric discharge, and that these reactions take place in rarefied atmospheres of the rare gases. High potentials are needed, and helium gas seems to answer best. Those are not encouraging features for the technical outlook; but the rare gases are not so very rare after all, and they have proved useful already in various ways. The cheaper argon can also be used at lower potentials and higher gas pressures than helium.

Professor Skaupy refers to one problem that might be solved by this method, the separation of neon into the two constituents, of atomic weights 20 and 22, which Sir J. J. Thomson assumes to

exist on the ground of his positive-ray analysis. Before the war Mr. J. W. Aston was engaged in the Cavendish laboratory in very laborious experiments for isolating the two constituents by means of many fractionations and diffusions. We do not know whether these experiments have since led to any definite result. But another point, not mentioned by Professor Skaupy, occurs to us. When the discharge is sent through vacuum tubes supposed to contain one gas only, the glows at the two electrodes look different, and they change somewhat as the discharge continues. Those differences and their variations might partly be due to the presence of impurities and to the gradual demixing of the constituents which the gas undergoes during the discharge. In the case of neon the distinction would be difficult if the two neons have the same spectrum, as Aston believed.

CHEAP ELECTRIC POWER IN GERMANY.

BEFORE the war the Germans were moving in the direction of supplying cheap electric power over wide areas in order to facilitate manufacture. In most of the States constituting the German Empire there were already many supply stations, denominated on the Continent "centrals," which were doing excellent work. But when the dream of a short campaign and a splendid triumph was rudely dispelled by the battle of the Marne, followed by the successful resistance of the French and British armies against all attempts to break their lines, the necessity of preparing for the commercial war, which it was foreseen would follow the long-drawn conflict on the field, led to immediate action to secure a still cheaper supply of electric energy over wide districts. To attain this end strenuous attempts were made to effect combinations among the various supply stations, so that all unnecessary expense might be avoided. These efforts are still in progress; but already a large measure of success has been attained, and no effort will be spared to reduce to the lowest possible figure the cost of electricity.

In the Kingdom of Saxony a decree was passed in the spring of the present year dealing with the future development of a State supply of electric energy. Owing to her concentrated industry and her rich coal, and especially lignite deposits, Saxony possesses some excellent conditions for a monopolisation of the supply of electric energy. On the other hand, difficulties of some magnitude may arise from the fact that the country already possesses a large number of electric works. The following table throws some interesting light on this point, and upon the enterprise of the large German electric companies in the matter of constructing large central stations :—

Nature of the Undertaking.	Number of Districts and Name, &c.	Number of Kilowatts Installed in 1914.	Number of Local Districts.
Private works without distribution system	36 districts	3,993	—
Private supply companies' concerns—			
Undertakings of the Allgemeine Elektricitäts Gesellschaft	4 large centres	44,350	277
Undertakings of the Siemens-Schuckert Combine	4 centrals	13,610	196
Five private companies and undertakings	13 districts	16,898	2
Municipal works	62 districts	119,985	658
Municipal combines	8 concerns and districts	22,440	987
Mixed industrial undertakings	4 concerns and districts	5,271	573
Supply works with State participation (1915)	The Himmerfürst concern	1,450	5
Other undertakings, tramways, &c., including State works for railways, &c.	5 undertakings	12,890	—

The aggregate number of kilowatts, as shown in the above table, amounts to 240,884, but one of the Allgemeine Elektricitäts Gesellschaft's stations had some further 13,000 kw. installed in 1916, and there may be other slight modifications as regards overlapping of areas, &c. The consumption of electric energy in Saxony during 1914 amounted to some 229,000,000 kw.h., of which the smaller private electric works only supplied about 1 per cent.; about 59 per cent. was supplied by the municipal works and 9.5 per cent. by municipal combines, whilst 21 per cent. was delivered from the private supply companies, and the mixed undertakings only supplied 5.7 per cent. It should, however, be noted that about 68 per cent. of the consumption of the municipalities and parishes and the municipal combines was taken from the energy-supply districts of the towns of Dresden, Leipzig, Chemnitz, Plauen, Reichenbach and Zittau.

Of the aggregate consumption of electric energy from the public electricity works in Germany, amounting to about 1,900,000,000 kw.h., about 11 per cent. took place in Saxony, although the area and number of inhabitants are only respectively 2.8 per cent. and 7.3 per cent. of that of the German Empire. As regards the capacity of the plant, that of Saxony is about 9.1 per cent. of the aggregate capacity of about 2,500,000 kw. of the German Empire, considerably above its proportion according to area. The capital invested in the electric generating works of Saxony, exclusive of the last group in the above table, amounts to about 247,000,000 marks, of which total about 88,000,000 marks are debited to the works or power stations proper and 159,000,000 marks to the distribution lines.

The large electric companies have manifested much energy in extending their respective systems, which fact caused the Union of Burgomasters in Saxony some five years ago to draw the attention of the Government to the danger entailed by this movement as far as municipal and State supply of electricity was concerned. A couple of years later the Union of Burgomasters formed a combine for the advancement of their joint interests in this connection, as against the company monopolisation of the electric supply. This combine, the *Elektroverband*, also planned the acquisition of coalfields, in order to generate the energy at the pits and transmit it to the different towns at a high voltage.

The Kingdom of Saxony, since the year 1912, has purchased extensive lignite deposits in the western and eastern portions of the country. Compared with coal and lignite, water power is but of small importance in Saxony. The desirability of a State generating and distributing system of electric energy becomes all the more manifest when viewed in connection with the electrification of railways, in which respect excellent results have recently been achieved in Prussia, Sweden, Switzerland and America.

In conclusion, it is to be pointed out that the State does not propose State electricity for the purpose of benefiting the revenue, but first and foremost with a view to supplying the country with cheap electric energy.

As many electric supply stations will have to face extensions in a near future, it will be advantageous to advance the State scheme as promptly as possible, but as money is likely to remain expensive for some time to come the expenditure must be confined to what is absolutely necessary. Both these considerations will be met by the new scheme retaining as many as possible of the existing works.

The Government scheme is as follows :—

1. The State lignite deposits in the east of the country and available for the generation of electricity lie east of the railway Zittau-Görlitz, between Hirschfelde and Reichenau. The river Neize, with sufficient water, is quite close, and the place altogether is admirably suited for the construction of the eastern State power station. The Electricity Supply Company of Berlin, one of the Allgemeine Elektricität Gesellschaft concerns, already has a power station there of 25,000 kw. capacity. The State has secured the option of these electric works for a sum of 5,000,000 marks. The fuel comes from the Herkules Lignite Company, with which there is a long-period contract.

2. The extension of this eastern power station and the construction of a large new power station on the western State lignite field will be made dependent upon the supply which will be apportioned to these two stations in the entire State scheme. This arrangement, besides the surface working of the State lignite deposits, will also comprise regulation as regards the larger modern electric supply station in western Saxony. A supply scheme will have to be worked out for the entire country, containing the main systems of all necessary high and medium voltage lines, of which the State means to become possessed to the same extent as had been planned by the *Elektroverband*. Next, the State will construct main lines, to assist in the exchange of energy between the existing power stations, pending the completion of the second large State power station.

3. Pending the completion of the electric generation and supply, there will have to be a series of intermediate stages in cases where certain municipalities have generating stations of their own, the Government being willing at once to make agreements. Should the expectations of the State, that the entire energy supply of Saxony will some day be drawn from the State system, come true, conditions will prevail which will enable the State to fix the lowest prices for electric energy.

During the past few weeks the Saxon Diet has voted the first grant of 20,000,000 marks, which, however, only represents a comparatively modest beginning, inasmuch as the scheme will entail an outlay of probably between 100,000,000 marks and 200,000,000 marks. The Hirschfelde power station has been purchased by the State, and the State supply of electric energy is intended to commence with the beginning of next year (1917). At first attention will be particularly directed towards the large private concerns, whilst the municipal and union electric centrals in the meantime will be left out of the Government scheme; their subsequent absorption, however, is reckoned upon. The Government has already notified a number of landowners in the Lausitz district that the State intends to work possible lignite deposits on their property, and that borings will immediately be proceeded with for the advancement of this object. The Government does not intend to purchase or expropriate the land in question, but the owners will receive a fixed sum as rent, which is double for surface deposits of that for underground deposits. After exploitation the land is to return to the owner in such a state that it can be cultivated. A measure has been passed vesting in the State the monopoly of searching for and working coal deposits, the exploitation of which has not already been commenced. In Saxony no mining claims can be lodged; anybody desirous of exploiting any deposits must purchase the land on which they are found. This has tended to develop unsound speculation, from which the State itself has suffered materially, having had to pay heavy commissions on its extensive purchases of lignite and coal deposits during the last few years, amounting in the aggregate to some 56,000,000 marks. In Prussia, it may be mentioned, a similar law has been in force since the year 1909. The measure in question in Saxony came into force at once—in fact, it had a retrospective effect of a week or two—and it remains in operation until June 30, 1918. A direct monopoly legislation is likely to take place, probably at the beginning of next year.

Bavaria comes next to Saxony in the matter of enterprise as regards State electricity. A report of 1913 emphasizes the necessity of placing the supply of electric energy of the country on a broad basis, through the aid of the State, and since then a detailed plan has been worked out and sanctioned by the Bavarian Diet. This plan outlines a combination of the Bavarian energy-generating works in one concern, which in the meantime has been named the *Bagernwerk*. In contrast to the Government scheme for Saxony, the one for Bavaria is based upon the eventual exploitation of waterfalls, as the country is poor in coal. The plan contemplates the supply of electric energy to that portion of the country which lies on the right side of the Rhine, and its most important feature is the exploitation of the Walchensee water power. It is proposed to lead the water of the Isar to Walchensee through the Obernach valley. In addition, the fall between Sachensee and Walchensee is intended to be utilised later on, for which purpose a tunnel of about 2½ miles length will have to be constructed. The fall is about 60 m. (197 ft.), and a volume of water of 16 cub. m. per second is reckoned upon. The Walchensee or Kochelsee power station will have a

substantial capacity, eight units of 10,000 h.p. each, of which, however, only six are intended to be installed at once, and it is proposed to transform the energy up to 100,000 volts.

It is proposed to combine the Walchensee and the additional hydro-electric power stations and all other power to be generated from State or private water power in one large concern, the *Bagernwerk*. For the completion of the scheme some steam central stations may be joined, which on account of the cheap coal are able to produce electricity at a low price.

In Baden the question is likely to be handled in a similar manner, the same views, in any case, being to the fore. It is a case of exploiting the country's water power. The energy from the Murg power station is to be supplied to companies, communities or municipal concerns as wholesale receivers, and this part of the supply is entirely reserved for the State by means of State lines. The plan, once mooted, of entrusting this part of the work to a company, of which the State could have secured the control, has been dropped.

In Prussia, where Imperial schemes have at times been to the fore, a strictly Prussian State electricity supply has not met with the attention its advocates seem to think it deserves.

Pending an increased activity in this direction of the State, the province of Brandenburg has taken the matter in hand, and has even entered upon a mixed arrangement, such as used formerly to be denounced by the bureaucracy as undesirable and undignified. The contracting parties are the province of Brandenburg, the Allgemeine Elektricitäts Gesellschaft, and the Prussian Crown. The province of Brandenburg takes over 7,000,000 marks of the share capital of 12,000,000 marks, of the Märkische Electricity Company, the rest can be taken over after a lapse of 20 years. The concern will be carried on as a mixed industrial undertaking, in which the Allgemeine Elektricitäts Gesellschaft, as regards the delivery of material and plant, and so far as the existing works are concerned, hold what may be termed a "most favoured" position. The Berlin suburban electricity works are also included in the combine.

A second part of the scheme regulates the relations between the Märkische Electricity Works and the Prussian railway department. The railway department has, it should be understood, made an offer to the province of Brandenburg respecting the joint concern to deliver energy for the electrification of the Berlin *Stadt* and *Ring* railways, after the completion of the large power station at the Bitterfeld lignite deposits, either delivered at the power station or transmitted to Berlin, according to the wishes of the province, in which latter case the cost of transmission is to be added. The price is such that it offers the province of Brandenburg very material advantages as compared with the cost of generating energy at its own power stations. Yet the generation of current at these stations will not be entirely discontinued, and they will not be reduced to simple distribution stations, but they will serve as what in Germany is called *Spitzenwerke*, and in this capacity supply extra demands, both as regards time and place. As long as the supply of energy from the new Bitterfeld power station of the State railway department is not available, which is likely to be for several years, the old works of the new mixed undertaking will have to cover the entire demand for energy, for which purpose some extensions may prove necessary.

NOTES.

The Smelting of Mercury Ores.

Mercury is one of the metals for which the war has created an exceptional demand, as the mercury fulminate forms the chief constituent of the detonators for small arms ammunition, as well as for torpedoes, floating mines and high explosives. We see from an article written by Mr. W. H. Landers, chief engineer of the New Almaden Company, in California, that the mercury mines of Almaden, in the centre of Spain, are historically the most famous. Since 1875, when the Scott tile furnace was introduced, Mr. Landers points out in the *Engineering and Mining Journal* of last October, little progress has been made in the metallurgy of mercury. But the diminishing grade of the available cinnabar, practically the only mercury ore of importance, calls for a careful investigation of all possible methods. At New Almaden ores of 5 per cent. were smelted about 1870, whilst during the last five years the average mercury content has been less than 1 per cent. The methods used have been rough, moreover; ore lumps ranging from the size of a man's fist have been charged directly into the furnace together with blocks weighing several hundredweights, without due sampling and assaying of the ores. Up till 1915 mechanical furnaces and wet processes were not in use. The continuous coarse-ore furnaces of the lime-kiln type which are most generally employed are satisfactory on the whole; but the small-size "fine" ores now mined in pieces of less than 1½ in. require some special treatment; briquetting has not been successful so far, however. The trouble is the lack of a suitable binding material; substances which evolve hydrocarbons, which would subsequently be condensed together with the mercury, have to be avoided, and oil fuels are, on the whole, hardly desirable, because they yield a greasy soot; they are used in California, however, the oil being burnt in large fire-boxes. Wood makes the best fuel. Retorts of cast-iron are used only in small plants, but may become more important again to deal with rich ore concentrates from wet processes. The multiple hearth roasting furnaces of Herreshoff are still in the experimental stage in mercury works; but they are being developed, and being easily controlled and more economical in fuel consumption than the Scott furnaces, they attract much attention. Mr. Landers himself describes in the same number of the journal mentioned a quicksilver-distilling furnace of his own, a combination of a multiple-hearth roasting furnace, dust settler and condenser. In view of the large mercury losses in tile furnaces, which may reach 40 per cent. with fine ores, wet processes for extracting mercury from concentrates look promising; the losses are due to absorption of mercury by the brickwork (from which the metal can finally be recovered when the furnace is dismantled), to air leaks, stack or exit losses (a very serious cause of waste) and to the floured mercury leaving the condensers together with the water. On the other hand, there is difficulty with the extraction of amorphous cinnabar from some ores; in many cases more than 90 per cent. of the mercury can be extracted, but sometimes the yield hardly exceeds 60 per cent. Flotation is being introduced at New Almaden.

Indian Railways.

The history of the Indian railways is a record of the zeal and ability of British engineers. It recalls a saying of George Stephenson, "If the country will make the railways, the railways will make the country." It also shows the need in our governing classes of greater imagination and insight in providing for the future. Every increase in railway facilities has been countered by a greater increase in traffic, and with a population of 324,000,000, who only make 1.41 journeys per annum each, the possible expansion is enormous. The first line, that from Bombay to Thana (21 miles), was opened on April 18, 1853, and by 1871 the railways open for traffic measured 5,074 miles. The growth since then has been fairly uniform, from 8,996 miles in 1880 to 35,286 miles in 1915. The number of passengers between 1880 and 1900 barely kept pace with the increase of mileage, but at the latter date the rate of increase suddenly grew. In 15 years (1900–1915) the length of line rose by 40 per cent. and the number of passengers by 140 per cent. Curiously the spurt in the goods traffic came 10 years earlier, and the increase since has been nearly uniform. In the period 1891–1915 the length of line increased by 115 per cent. and the weight of goods lifted by 260 per cent. The proportion of working expenses to gross earnings is satisfactory, but, as in most other countries, it now tends to rise. From 1880 to 1900 it fell from 50.37 per cent. to 47.4 per cent., but now it stands at 51.87 per cent. Fortunately, the gross earnings per mile per week have risen, being 16.76*l.* in 1900, 18.97*l.* in 1910, and 22.79*l.* in 1914. The average net returns are now just over 6 per cent., and since 1900 the average annual surplus has risen from 1.6 millions sterling to 4.8 millions. The fact that the Indian railways have been able to deal with such a large increase of traffic so successfully is largely due to the engineers responsible for the locomotives and rolling-stock. We learn from a lecture delivered by Mr. H. Kelway-Bamber, M.V.O., before the East India Association this summer, that the power of mail and passenger locomotives has increased since 1900 by 26 per cent. on the broad gauge (5 ft. 6 in.) and 80 per cent. on the metre gauge. The maximum weight of main line passenger trains is 400 tons on the broad and 300 tons on the metre gauge, while for goods and mineral traffic the maximum weights are 1,600 and 1,000 tons. The average work done by goods and passenger engines, as represented by the total ton-mileage hauled, has increased during the past 24 years by about 45 per cent. Great improvements have been made in the passenger and goods stock, many of them by Mr. Kelway-Bamber, who was formerly superintendent of rolling-stock on the East Indian Railway. Until 1902 the broad-gauge third-class carriages were 4-wheeled, seated 60 persons, and had no lavatory accommodation. Now they carry 126 passengers, and with vacuum brakes, electric light and lavatories the weight works out at ½ ton per passenger. The fares are one-fifth of a penny per mile. In 1895 the permissible total weight per axle for broad-gauge lines was 9 tons, while the standard four-wheeled wagons weighed 6 tons and carried 12. By 1906 the maximum weight per axle had been increased to 16 tons, at which it remains. The most recent type of four-wheeled wagons weighs 8.75 tons and carry 23.25 tons. On one of the principal Indian broad-gauge lines the average carrying capacity of wagons has increased from 1,906 to 1,915, nearly 16 per cent., the load per mile by over 27 per cent., the average mileage run per wagon by over 13 per cent., while the cost of hauling 1 ton per mile has decreased 31 per cent. Owing to the restriction in width of carriage and wagon bodies, due to the loading gauge, it has not been possible to take advantage of the facilities the broad gauge would otherwise afford. The inside body width of the 5-ft. 6-in. gauge is 9 ft. 4 in., whereas on the United States standard gauge it is 9 ft. 5 in. On the metre gauge it is 7 ft. 5 in., and on the 2-ft. 6-in. gauge, 6 ft. 4 in. Much of the improved working has been due to the introduction of steel carriages and of pressed steel wagons, and more will be accomplished by these means as the old stock wears out. The use of smaller wheels will also allow deeper bodies for the wagons.

Training Returned Soldiers and Sailors.—The Governors of the Royal Technical College, Glasgow, at the request of certain donors, offer prizes, amounting to 70*l.*, for essays on the best methods of training and employing in industries, other than agriculture, returned soldiers and sailors, maimed or otherwise. The prizes will be awarded by a committee of the governors, and may be withheld in the event of no essay of sufficient merit being submitted. The decision of the committee on this and all other points will be final. Essays must be sent in not later than March 1, 1917, addressed to The Director, the Royal Technical College, Glasgow.

"Isherwood" System of Ship Construction.—The number of "Isherwood" vessels contracted for to date in this year is 152, with a total gross tonnage of about 698,875, which is equivalent to about 1,000,000 tons in deadweight-carrying capacity. thus making the total number of vessels built, under construction and on order 620, with an aggregate deadweight-carrying capacity of over 4,500,000 tons. Whilst the "Isherwood" system has achieved an overwhelming predominance in some types of craft, the following analysis of the 620 vessels referred to above shows most distinctly the suitability of the system for all types and classes of vessels:—265 oil-tank steamers, aggregating 2,413,750 tons deadweight-carrying capacity; 25 colliers and ore steamers, of 255,000 tons deadweight-carrying capacity; 9 passenger vessels, of 44,600 tons deadweight-carrying capacity; 24 Great Lakes freighters, of 279,060 tons deadweight-carrying capacity; 73 barges, of 25,850 tons deadweight-carrying capacity; 221 general cargo vessels, of 1,645,200 deadweight-carrying capacity; 2 dredgers, of 760 gross register tons; 1 trawler, of 570 gross register tons. In the United States of America well over 90 per cent. of the oil-tank tonnage at present under construction and about 50 per cent. of the total merchant tonnage is claimed by the "Isherwood" system, as is also a very large proportion of the merchant ships now being built in Japan.

THE LATE MR. ROBERT HARVEY BURNETT

WE regret to have to record the death, which occurred at his residence, 21, Denbigh-street, Warwick-square, S.W., on the 13th inst., of Mr. Robert Harvey Burnett. Mr. Burnett was born in May, 1838, at Ardross. He was educated at the Hawarden Grammar School, at the King's School, Chester, and later, in 1855–56, at the University of Glasgow. At the age of eighteen Mr. Burnett became a pupil of Messrs. Beyer, Peacock and Co., Gorton, Manchester, in whose drawing office he worked for several years after the completion of his apprenticeship in the workshops. In 1862 he was sent by them to Bilbao, to superintend the delivery and starting of a large number of locomotives constructed by the firm for the Bilbao and Tudela Railway. On his return, in 1863, he conducted at the Gorton works a number of experiments on locomotives destined for the London Metropolitan Railway. On the delivery of these engines, in 1864, Mr. Burnett, having then barely completed his twenty-fifth year, was appointed, on the recommendation of the late Sir John Fowler, locomotive superintendent and resident engineer of the Metropolitan Railway, in order to take up the working of the line with the new 4-ft. 8½-in. gauge rolling-stock, the first portion of the line opened having been of broad gauge, and worked in connection with the Great Western Railway.

Mr. Burnett retained this position for a period of eight years, during which time the Metropolitan and District railways largely developed in length and in traffic. In the course of his connection with the Metropolitan Railway it devolved upon Mr. Burnett to design locomotives for working the St. John's Wood branch, having a gradient of 1 in 27, wholly in tunnel, with a station midway. The locomotives having to be worked condensing while traversing tunnel, and a falling steam pressure consequently having to be dealt with, it was necessary that the locomotives used should have large cylinder power, and Mr. Burnett designed for the service six-coupled engines having 4-ft. driving wheels and inside cylinders 20 in. in diameter, such proportions being quite unusual in those days. His connection with the Metropolitan Railway terminated in 1872, when an entire change of the board of directors took place. He then resumed his connection with Messrs. Beyer, Peacock and Co., and after a short time was appointed their works manager, which position he held until 1877, when a failure in health led to his resignation.

After twelve months of entire rest Mr. Burnett was selected by the Agent-General for New South Wales, also on the recommendation of Sir John Fowler, as locomotive engineer to the Government Railways of that Colony, which were then about 700 miles in length. He occupied that position for four years, during which time the mileage of the lines rose to over 1,000 miles, necessitating large additions to the rolling-stock, for the design and construction of which Mr. Burnett was responsible. He resigned his appointment in 1882, and returned to this country, settling in Westminster, where he practised as a consulting engineer until 1889.

He then, for the second time, rejoined the firm of Beyer, Peacock and Co., where his experience and his intimate knowledge of the company's business enabled him to render valuable aid in the carrying out of contracts for railways abroad. In 1903 the firm was converted into a limited liability company, and in 1905 Mr. Burnett retired from active connection with the concern, with the position of consulting engineer to the company. In 1911 he was requested by the board of the company to take up the position of their representative at their London office, 14, Victoria-street, which position he held until his decease.

Mr. Burnett was elected an associate member of the Institution of Civil Engineers in 1866, and a full member in May, 1871; he was also elected, in 1878, a member of the Institution of Mechanical Engineers, but resigned his membership in 1906. Mr. Burnett was widely known in the railway world, and the news of his death will be received with much regret by a large circle of friends.

EXPLOSIONS IN COMPRESSORS FOR DIESEL ENGINES.—The Diesel Engine Users' Association, of 19, Cadogan-gardens, London, S.W., have just published, price 1s., a report by a committee appointed by them to investigate air-compressor explosions. The immediate occasion of the inquiry was an explosion in the air compressor attached to a Diesel engine belonging to the Smithfield Markets Electric Supply Company, Ltd., but a number of similar accidents had occurred previously, and these have also been investigated by the committee. The committee conclude that these explosions are caused by the firing of vapour from the lubricating oil, and have embodied in their report a considerable number of detailed recommendations as to the construction and operation of Diesel engines, which, if insisted on, should greatly diminish the risk of such occurrences in the future.

SURVEYORS AND EXEMPTION FROM MILITARY SERVICE.

WE have received from the Surveyors' Institution the following statement of the important action taken by the Council of that body with regard to the desirability of securing exemption from military service for professional men under certain reasonable conditions:—

"Under Section 2 (1) (*b*) of the Military Service Act, 1916, the Legislature recognised that exemption from military service might be justified on the ground that serious hardship would ensue if a man were called up for army service, owing to his exceptional financial or business obligations or domestic position.

"In the view of the Council this provision would apply specially to the cases of men who are the sole, or sole remaining, heads of businesses on which they or their families are dependent for a livelihood, and who are unable to find a substitute to carry on their business, which would therefore be ruined if they went. The Council have carefully considered how best they might assist members placed in that difficulty, and they have decided:—

"1. To set up boards, both for the London area and for provincial districts, to investigate applications for exemption from members, and to advise the Tribunals thereon. Members called up before Tribunals are therefore advised to ask that their cases may in the first instance be referred to the board representing their district; and

"2. To set up a court to deal generally with questions connected with the maintenance of the businesses of members called to the Colours, and to adjudicate upon differences which may arise between them and other surveyors who may be acting for them.

"The Institution has been asked to make it known that surveyors in all branches of the profession, who have now been called up for military service, will be accepted for the 110th Training Reserve Battalion (late 22nd King's Royal Rifle Corps), from which a number of surveyors have already obtained commissions, and in which they will have the opportunity of being trained with other men of the professional classes. The Battalion is stationed on Wimbledon Common. Applications should be made to the British Empire League, Norfolk House, Laurence Pountney Hill, E.C., letters being marked 'Recruiting.'"

THE OPTICAL SOCIETY.

A MEETING of the Optical Society was held at Burlington House, Piccadilly, on December 14, the president, Mr. F. J. Cheshire, in the chair. Mr. F. S. Berrett, Mr. Chas. Lees Curties, Mr. F. S. B. Ellis, Mr. J. W. Hasselkus, Prof. H. Jackson, Mr. Horace Lee, Dr. T. R. Merton, Prof. J. W. Nicholson, Mr. L. V. Riquez and Mr. Wm. Simms were elected members of the society and Mr. Eric L. Ebbage a student member.

A paper experimentally illustrated, on "*The Refractometry and Identification of Glass Specimens, especially Lenses*," was read by Mr. L. C. Martin, D.I.C., A.R.C.Sc., B.Sc., of the Imperial College of Science and Technology. The author pointed out that the determination of the refractive index generally requires at least one plane polished surface in the specimen, but the method he described could be used for lenticular, irregular or unpolished pieces of glass. By immersing the specimen in a liquid of equal refractive index the system became optically homogeneous for light of a particular wave-length. The liquid, which may be a mixture of carbon disulphide and alcohol or a solution of mercuric potassium iodide, is contained in a prism cell on the table of a spectrometer and is kept mechanically stirred. Spectra from the usual sources are observed by refraction through the prism, of which the sides are plane-parallel glass. The introduction of the specimen diffuses the light, but any particular spectrum line may be focused by adjustment of the strength of the liquid. The refractive index of the liquid and specimen is then found in the usual manner. Advantages of the method are its simplicity and availability for direct measurement on light from a hydrogen vacuum tube. Defects in specimens such as binocular prisms when unpolished are very easily observed by immersion in such a liquid.

Two direct-reading instruments for curvature were also described by Mr. Martin. In one of these the surface (convex) is pressed against a stop, when a ray of light parallel to the axis passes through a pinhole and meets the edge of the stop, being reflected at an angle with the axis depending on the radius of curvature. It is found by means of a second pinhole in a plate sliding against a scale; a fiducial mark indicates the radius of curvature. In the second instrument the lens is mounted on the top of a pendulum rod; this projects above its axis by an amount adjusted to be equal to the radius of the lens surface, when objects seen by reflection will appear stationary while the pendulum vibrates.

Dr. Reginald S. Clay contributed a paper describing "*A Workshop Method of determining the Refractive Index of a Block of Glass, of which only one face is Polished.*" The method was shown to be based, as are the Abbé and Pulfrich refractometers, upon the determination of the critical angle when light passes from the medium of which the refractive index is to be found into one of which the index is known. The hemispherical ball of Abbé or the cube of the Pulfrich refractometer is replaced by an isosceles right-angle prism. This must, of course, have a higher refractive index than that of the substance it is required to measure. A simple telescope, composed of two spectacle lenses with a cross-wire at their common focal plane, is used to take the readings. A drop of liquid of high refractive index (*e.g.*, quinoline or oil of cassia) is placed on the hypotenuse face of the prism, and this is placed upon the polished face of the glass of which the refractive index is required. Sodium light is caused to fall on one side of the block of glass, and the light emerging from one face of the prism is received by the telescope. The latter is turned until the critical angle is obtained, shown by one-half of the field of the telescope becoming black, and the dividing line of the field being on the cross-wire of the telescope. The observation is repeated for light falling on the opposite side of the glass block and emerging from the other face of the prism. The angular distance between the two positions of the telescope determines the refractive index of the glass by a simple calculation, or the scale can be divided to give the refractive index directly. If the scale is divided into degrees, a curve can be drawn to give the refractive index when the angle is known.

If only rough readings are wanted, a scale can be constructed experimentally by observing the angle between the two positions of the telescope with four or five specimens of glass of known refractive index, plotting the deviations obtained against the known indices, and then drawing a smooth curve through the points obtained. Even in this way there should be no difficulty in getting the third decimal within one or two units.

In making the telescope, which can be of about unit magnification, the eye ring should be arranged to be conjugate to the prism, i.e., the eye is to be placed some distance beyond the Ramsden circle. Practically the whole apparatus shown by Dr. Clay was made of wood.

Mr. Irvine Aitchison, Mr. F. Twyman, Mr. S. D. Chalmers, Mr. J. W. Hasselkus, and the president took part in the discussion which followed, and a vote of thanks was accorded the authors. It was announced that the society, at the request of the Ministry of Munitions, is arranging for an exhibition of workshop methods of optical testing to be held at King's College, Strand, on Thursday, January 11.

UNIVERSITY OF BRISTOL.—We have received a copy of the new almanack of the University of Bristol. The engineering courses here are divided into: civil engineering, under the direction of Professor R. M. Ferrier; automobile engineering, under the direction of Professor W. Morgan; mechanical and mining engineering, for which Professor R. Munro is responsible; and electrical engineering, directed by Professor D. Robertson. There is also a department of applied chemistry, under Professor J. Wertheimer. Of these full particulars can be obtained on application to the registrar.

THE ELECTRIC CONDUCTIVITY OF PURE WATER.—Evidence has recently been accumulating in support of the assumption that the very small specific conductivity of pure water (in contact with air), which is about 0.7 or 0.8×10^{-6} mho, is practically due to the absorption of carbon dioxide from the air. In testing this assumption, Mr. James Kendall, of Columbia University, New York (Journal of the American Chemical Society, vol. xxxviii, pages 1480–1497) redetermines both the conductivity of solutions of carbonic acid in equilibrium with the atmosphere and of acid carbonates, and the percentage of CO_2 in the atmosphere. This latter percentage he finds to be about 0.035. The conclusion drawn is that the small conductivity of pure water—itself regarded as an insulator—which might be due to traces of salts and to impurities taken from the vessels and from the air, would be sufficiently accounted for by the presence of carbon dioxide.

"ECLIPSE OR EMPIRE?"—Under this striking title Messrs. Herbert Branston Gray and Samuel Turner have published a small book to impress upon the man-in-the-street that our industrial supremacy has, during the last 40 years, been threatened and, in part, usurped by alien powers, gradually, stealthily, but unmistakably, and often in spheres which once seemed peculiarly our own. They state that the force of the book lies rather in facts and figures than in opinions and inferences. It seeks to stimulate further inquiry, while it concentrates public thought. More than half the volume is devoted to a "glossary" to demonstrate the truth of this postulate: "That during the last 20–40 years most of the inventions, new ideas and developments have been given to the world by countries other than our own; furthermore, that their value has been more quickly appreciated and put to practical use in foreign lands." Four chapters of this glossary refer to various phases of engineering, and in these the authors give more than ample credit to foreign countries. We think that they do not sufficiently distinguish between ideas and developments. It is unfortunately too true that ideas which meet with a chilling reception here are often given a warm welcome in other countries. Occasionally the authors have let their desire to rouse the British manufacturer override the necessity for accuracy, as in the following statement: "Until recently the mechanism for the closing of watertight doors in a ship was the monopoly of two firms—both foreign. The Stone-Lloyd (hydraulic) system is a German scheme which has been taken up and developed by a British firm, and is at present the system most fitted in this country. The other design . . . is the method adopted in America." Messrs. J. Stone and Co., Limited, of Deptford, called the attention of the publishers, Messrs. James Nesbit and Co., Limited, of 22, Berners-street, to the fact that all the patents for the Stone hydraulic system in use in the British Empire are the invention of British engineers.—Messrs. Nesbit have, therefore, withdrawn the statement in question, and have apologised for its appearance. The object of the book is one with which we all sympathise, and if it brings home to us in any degree the necessity of greater thought and more vigorous action it will have accomplished a good work.

BOILER EXPLOSION AT PAISLEY.

A formal investigation has been conducted at the Sheriff Court, Paisley, by the Board of Trade, under the Boiler Explosions Act, 1882, with regard to the cause and circumstances of an explosion which occurred at Messrs. MacKean's, St. Mirren Starch Works, in that town, on July 26 last.

The Commissioners were Sheriff Christopher North Johnston and Mr. Charles Cormack. Mr. T. W. Donald, writer, Glasgow, appeared for the Board of Trade; Mr. Andrew Aitken, Glasgow, for the Vulcan Boiler and General Insurance Company; and Mr. MacRobert for Messrs. MacKean.

In opening the proceedings on behalf of the Board of Trade, Mr. Donald stated that the boiler which exploded was officially known as a converter, a vessel in which starch was converted into glucose by means of steam. It was constructed in 1902, and was made of copper, the shell being said to have been $\frac{1}{4}$ in. thick at the sides, and $\frac{3}{8}$ in. thick at the ends. It was fitted with certain mountings in the way of valves, &c., and had apparently been erected at the works about 14 years ago. It had been in daily use ever since, and was last inspected in May, 1916. On the morning of July 26, a little before 9 o'clock, a charge was run into the converter, steam was turned on, and about ten minutes afterwards the boiler exploded. The object of that inquiry was to ascertain the cause of the explosion, whether it could have been prevented, and, if so, whether anyone was to blame. Mr. Donald submitted to the court a list of questions bearing upon the facts which had to be elicited during the course of the investigation.

A number of witnesses were then called, the first being Mr. Alfred Norman Peacock, engineer-surveyor to the Board of Trade, a post which he stated he had held for 25 years. On August 29 last he sent in a report of a preliminary inquiry with regard to the explosion, and found that the vessel in question was used for converting liquefied starch into glucose, steam being admitted into the liquid in order to effect the conversion. Witness gave the court a full description of the make of the boiler, dimensions, &c., &c., and stated that it was emptied by pressure. In regard to any repairs effected since the boiler had been constructed, he ascertained that a new discharge valve had been fitted, and the internal steam pipe had been renewed, while, in place of the lever safety valve, previously used, an open spring valve had been fitted, and the air-cock had been substituted by a valve. The converter was used every day except Saturdays, Sundays and holidays. Witness fully described the process of conversion, and stated that the steam used was supplied by the factory boilers at a working pressure of 180 lb. per square inch, but before it got to the converter the pressure was reduced until it was apparently intended to be lowered to 45 lb. The working pressure for the converter was, according to the information he had obtained, 40 lb., and he understood it was originally constructed for 50 lb., but in the works the pressure generally was supposed to be 40 lb. He found that the valve in one place was badly corroded, and it would have leaked considerably if it had not been obstructed, but it was impossible to verify if it were stuck or not. From the examination he had made of the boiler, it was evident that the explosion had been a very violent one, the converter having been completely burst open with a longitudinal rupture along the bottom. The cylindrical portion was projected from its seat, and fell 27 ft. away, completely breaking down a wall on that side of the building and landing on the flat below. The manhole end was blown completely out, breaking through a wall and falling into the street 19 ft. away from its original position: the other end fell 6 ft. away, and the mountings were mostly broken. Witness had made a very careful examination of the shell of the converter and found it was very much wasted and badly grooved and pitted internally. He thought that the internal rupture started in the thinnest part of the boiler. The end of the converter was supposed to be $\frac{3}{8}$ in. thick, and it was wasted from $\frac{1}{4}$ in. to $\frac{1}{32}$ in. The measurements he had taken showed that the thickness was very much less than the original, possibly less than one-half.

Mr. Donald, on behalf of the Board of Trade, at this point stated that the first object of these formal investigations was to warn other people of the dangers that might ensue from working certain boilers under certain circumstances.

In further examination by the commissioners witness explained that in his opinion the explosion was caused through the vessel having become wasted to such a degree that it could no longer withstand the pressure to which it was subjected.

The next witness, Mr. J. L. Ferguson, director of Messrs. Blair, Campbell and McLean, Govan, was examined at considerable length with regard to the construction of the boiler, the quality of the copper used and the probable effect of acids on the copper, and the age of the vessel.

Mr. W. M. MacKean, managing director of Messrs. MacKean's, was then examined at some length by Mr. Donald on behalf of the Board of Trade, with regard to the construction of the converter, and explained to the court the process adopted of converting the "starch milk" into glucose, in the course of which process, he said, a small proportion of sulphuric acid was used. The firm manufactured both solid and liquid glucose, and it was while the former was in process that the explosion occurred. They probably had five charges a day up to Wednesday, and six on Thursday and Friday, so that the converter was practically in constant use. In explaining to the court the machinery, valves, &c., witness mentioned that a "Foster reducing valve" which had been spoken about, had really nothing to do with the converter's protection. This department was but a small one, and all the testing was done by the foreman, except when he undertook a test himself. They had a works engineer to look after the general machinery, and he was assisted by two mechanics and two labourers, but had no special instructions to look after the converter. On the morning of the explosion there was what he considered a fair draw of steam on, but nothing like the maximum. As to the insurance of the converter, it had never struck him to insure it until 1914, when several matters of insurance connected with the Brewers' Sugar Company had come before him, and he had decided to insure. It was his opinion that when the vessel had been inspected and passed by the insurance company it would be safe to work.

At this point voluminous correspondence on the insurance of the vessel was submitted to the court, and in a report dated June 9, 1914, the Vulcan Boiler Insurance Company, under the heading "defects, if any," added the words "none seen." At a further examination made on September 5 of the same year the condition of the vessel was reported "in order." In March, 1916, an external examination was made by the company's inspector, when it was reported as "in order" and "no repairs required." Again on May 20 of the present year another inspector examined the boiler and reported it both externally and internally as in order, with the exception of pitting on the lower half $\frac{1}{16}$ to $\frac{1}{32}$ in. deep. That was the last examination made by the insurance company before the boiler exploded two months later, and witness stated that he thought the inspectors were probably wrong in saying that no repairs were needed. From what he had heard it was his opinion that there must have been considerable wasting of the copper plates, and that it must have been going on for a considerable number of years. The cause of the explosion, witness thought, was beyond doubt wasting of the shell of the boiler. He did not think that the steam pressure on that morning was any greater than usual, and the boiler probably burst at the usual working pressure. In his opinion the wasting was due to ordinary wear and tear.

In cross-examination Mr. MacKean said that having employed an insurance company thoroughly to inspect his boilers, he considered he was entirely relieved of undertaking the duty himself. His own engineer would, of course, take note of any temporary defects to which his attention was called. Witness had not been asked officially by the insurance company for any statement as to the nature and substance of the glucose which was put into the vessel. There had been no change in the process since the converter was put in.

The condition of the vessel and its capacity and fitness for carrying certain pressures of steam was then spoken to by three other witnesses, who had been employed at the works. The works chemist also referred to the question of the sulphuric acid having caused the thinning of the copper on the inside of the boiler. He thought the wasting had been a very gradual process, and his reasons for thinking this were: (1) that when sulphuric acid was introduced into a copper vessel at a high temperature, it must have a slightly solvent effect, and it stood to reason that that action had been taking place all the time; (2) had there been any sudden wearing action, and copper removed, that copper must have gone somewhere, and had it gone to the extent of the wastage in the converter, even during the time he had been there, it would have meant that there would have been a scientifically enormous quantity of copper in some of the glucose products. One analysis showed that in the ash of the glucose there were indications of copper, but the quantity was not enough to make a quantitative examination. The minimum amount that could be detected would be about 80–100 grains per ton, and there might be that amount, but not more.

Considerable evidence was then taken, dealing mainly with the insurance of the vessel, the custom of the insurance company with regard to this class of insurance, and the steps they might or might not be justified in taking when accepting or rejecting risks.

On the third day of the inquiry Mr. William Paterson, works engineer in the employ of Messrs. MacKean, stated that most of the machinery was under his charge as far as repairs were concerned. If anything went wrong, the heads of the departments reported to him and it was his duty to put it right; he did not exercise any general supervision, he simply repaired the plant and machinery, and it was not his duty to test the converter. With regard to the inspection made by Mr. Ramsay, the insurance company's representative, witness said that the inspector went inside the converter for a few minutes and struck blows with a hammer; he would be inside five minutes at the most. Witness noticed some slight pitting near the bottom of the valve. On the morning of the explosion certain machinery was working which would require a considerable amount of steam. He had never tested the reducing valve to see if it was working or not. His opinion as to the cause of the explosion was that it was a question of boiler pressure. Shown a piece of the bottom plate of the converter, witness admitted that it was pitted, but not seriously in view of the thickness of the metal.

Cross-examined by Mr. Aitken, on behalf of the Vulcan Boiler Insurance Company, witness said it was only since the explosion and inquiry that he had learnt much about the converter. In regard to the safety of the vessel, since he came back a second time to Messrs. MacKean's employ he took no special steps to satisfy himself, because he relied upon Mr. M'Cowan, who was in charge, and who would have reported any defect.

By Mr. MacRobert: Mr. Ramsay, the insurance inspector, when making the examination of the converter, did not ask him to go inside. If serious defects had been reported to him, he would have made an examination personally, but he did not consider it his duty to examine immediately after the insurance company had done so. In ordinary circumstances a boiler could be worked for twelve months after an inspection without being again examined.

By the Commissioner: Witness was a mechanic, and it was his duty to repair things which were out of order; he was a practical engineer and served his apprenticeship at Lanark, being afterwards foreman-in-charge of the engineering plant of Messrs. D. and W. Henderson, Glasgow. From 1912 till 1914 he was works engineer with Messrs. MacKean. He then went back to Messrs. Henderson, and returned again to Messrs. MacKean in 1916.

Mr. Wm. T. Gordon, inspector to the Vulcan Boiler Insurance Company, said he held an extra first-class engineering certificate, and had been in the employ of the company since 1910. In May, 1914, he made an external examination of the vessel and furnished particulars, and he would suppose that the measurements he then supplied to his firm would eventually be checked by them. Messrs. MacKean were willing to accept 35 lb. pressure, and subsequently his company agreed to allow 40 lb. as the working pressure.

By the Commissioner: The converter was never worked at a greater pressure than 35 lb. At his second examination he asked what was in the converter, and was told glucose, but he had no idea what was in glucose except that it was a food-stuff. It was not a practice of the insurance company to ask what was being boiled. In September, 1914, he made a thorough internal examination, and then discovered a vertical groove, but no pitting, though there might have been some wasting since 1914. When he tested the boiler with the hammer, he found it quite sound, and he could not say that he detected anything strange about it. If there had been a thin part, he thought he would have detected it, at least he hoped so; the last time he made an examination, in March, 1916, it was an external one—he could not get a thorough examination because some of the valves were leaking. He reported then that no repairs were required in the boiler. He had seen the converter since the explosion, and thought that the cause of the explosion was that the plates were too thin to stand the working pressure.

After one or two other witnesses had given evidence, the presiding commissioner, Sheriff Johnston, said that he and his brother commissioner had considered the case at the present stage without going into very minute detail, as it would be their duty to present to the Board of Trade a considered report which might contain certain recommendations with a view to avoiding similar accidents in the future. All they had to do at present, therefore, was to give a brief statement. They found the cause of the explosion was deteriorating and thinning away of the converter, due to the chemical action of the acid in the mixture with which the converter was regularly charged. Further, the commissioners found that the following were to blame in varying degrees, but they did not in any way impugn their integrity or professional ability:—Messrs. MacKean, with Mr. William Muir MacKean and Mr. Paterson, their engineer; the Vulcan Boiler and General Insurance Company, and Messrs. Gordon and Ramsay, their inspectors. The court directed that Messrs. MacKean and the Vulcan Boiler Insurance Company each contribute 50*l.* to the costs of the inquiry.

Mr. MacRobert, on behalf of Messrs. MacKean, having made a statement to the effect that 26*l.* had been spent by his clients in preparing plans and photographs, inquired if that could be included in the 50*l.* costs. The court, however, adhered to the 50*l.*, but suggested that the Board of Trade should pay half of the expenses of the plans.

Personal.—Messrs. Gaston, Williams and Wigmore, Limited, of Alexandra House, Kingsway, London, W.C., in consequence of the Ministry of Munitions having requisitioned the whole of the first floor of Alexandra House for purposes connected with the war, are obliged to move their general offices temporarily to International Buildings, Kingsway, W.C., but their motor sales department will still continue to occupy the showrooms on the ground floor as at present.

Geological Mapping.—In presenting "Notes on the Subject of Geological Mapping" to the meeting of the Institution of Petroleum Technologists, held on Tuesday, December 19th, Mr. S. Lister James, F.G.S., emphasised that a geological survey should always be the first preliminary towards the development of a new oilfield, and that the survey should have reached an advanced stage before the commencement even of drilling operations. The equipment of the geologist should comprise a leather map case, 12 by 9 in., hand compass and clinometer combined, tape-line, &c.; the map case was preferable to the plane table, as the latter had to be set up and did not admit of rapidly following up horizons. The notes also dealt with mapping in forest land.

The Late Mr. D. H. Thorold.—We regret to announce the death, on the 15th inst., of Mr. W. H. Thorold, who for more than 50 years had been a contributor to our columns. Although in his eighty-third year, he continued in active work until about 10 days before his death. The field of journalism which he had made his own was the collection of statistics in commercial, financial and industrial affairs. He had a vast store of facts at his command, and could trace the growth of industries and manufactures through long series of years. It would be possible to write a very fair history of commercial engineering from the paragraphs he sent to us. He lived at Norwich, and is survived by his widow, his daughter and his son.

ELECTRON, QUANTA AND RELATIVITY THEORIES.

TO THE EDITOR OF ENGINEERING.

SIR,—When "Sesamy" propounded the query: "How can an amount of energy or momentum *enter* at W, or anywhere else?" I concluded he was merely poking fun; but as it now appears it was a serious question, he is probably concerned with the so-called modern views of energy, which will be better comprehended by a quotation from Sir Oliver Lodge, "The Ether of Space," p. 29:—"Yet we know from the case of heat that a material movement can be excited in one place at the expense of corresponding movement in another, without any similar kind of transmission or material connection between the two places: the thing that travels across the vacuum is not heat." One purpose of the diagram (see page 515 *ante*) was to deny such an assertion by showing that in light vibrations there are hitherto-ignored longitudinal components which represent heat, and that the transverse electromagnetic components are merely the *reciprocating* forces of the ethereal pressure which acts as a perpetual motor, receiving and giving out energy by infinitesimal units h equal to 0.9×10^{-26} h.p. The whole of the kinetic energy is the sum of the longitudinal components, as evidenced by my interpretation of the Stark effect, thus giving the well-known longitudinal pressure of radiation. Energy can be transmitted across space in three fundamentally different ways only, namely:—(1) By the motion of a material particle; (2) by wave-motion of matter in bulk; (3) by material atomic wave-motion. Atomic wave-motion, with which we are now concerned, is dealt with by means of Maxwell's equations, and in crystalline media, which includes the ether, the two directions of displacement belonging to the same wave-plane (α, β γ in the diagram) are equal and perpendicular to each other in the plane of the wave, and are also conjugate in the ellipsoid, whose equation is $A^2 x^2 + B^2 y^2 + C^2 z^2 =$ constant. This is the sphere or ellipsoid of the diagram.

The pressure of $2p$ in the direction of propagation of the wave (Maxwell, Art. 792, p. 401) is due to two plena, each with a magnetic vector and a displacement vector also equal and mutually perpendicular. These axial vectors, multiplied together as a quaternion, give the longitudinal axial vector p for each plenum. It must be remembered that "an axial vector and a vector product are essentially two aspects of the same conceptions, the former being potentially resolvable into two factors determining an oriented area that is at the same time the geometrical basis of the vector product." The two plena, being independent and separable, readily account for the Zeeman effect. Thus "concrete significance is attached to the electrical magnitudes in terms of the constitution motion or distortion of this medium," as required by Professor E. Cunningham to reconcile the idea of a unique medium with the mathematical equations which do not determine a unique frame of reference.

FRED. G. EDWARDS.

33, St. Ronan's-road, Sheffield, December 16, 1916.

SCREWING SOLID-DRAWN STEEL TUBES.

TO THE EDITOR OF ENGINEERING.

SIR,—The difficulty mentioned by your correspondent "T.W.K." has been experienced by many. The toughness of the steel used in the manufacture of weldless tube requires a die with a more inclined cutting edge. The ordinary die made for wrought-iron or soft steel tube can be adjusted accordingly.

Yours faithfully,

B. R. PARKINSON.

420, Salisbury House, London Wall, E.C.,
December 19, 1916.

JAPANESE SHIPBUILDING.—The Japanese Government is considering the question of reducing the national assistance extended to shipbuilding. The assistance hitherto given was afforded so opportunely that when the great war broke out in Europe and many ships were diverted from commercial to naval purposes by the belligerents, Japanese shipowners made great profits. The highly remunerative freight rates earned by ships have been even a greater stimulus to the growth of Japanese shipping than the Government subsidies granted. This growth has, however, resulted in a heavy increase in the amount which the Government is now called upon to pay to shipbuilders. In 1914 these payments amounted to 815,000 dols., in 1916 they will be 1,561,000 dols., and next year they are expected to be about 2,900,000 dols. It is not surprising, accordingly, that the Japanese Treasury is casting about for some relief.

THE ALLGEMEINE ELEKTRICITÄTS GESELLSCHAFT.—The report of this company for the year 1915–16 showed continued improvement, and the year is the best on record, excepting 1912–13. The war-aid contribution to the families, widows, &c., of the company's employees at the front amounted to 7,548,359 marks, against 4,612,414 marks for 1914–15. Interests, writings-off, &c., having been provided for, the net profits amount to 27,193,409 marks, against 21,298,115 marks for the previous year, 18,892,641 marks for 1913–14, and 25,904,483 marks for 1912–13. The dividend has been fixed at 12 per cent., against 11 per cent. last year, on 155,000,000 marks, and 6 per cent. on 29,000,000 marks. A sum of 1,500,000 marks is added to a war welfare fund. Most of the 29,000,000 marks of new share capital has been applied to the acquisition of the Berlin Electricity Works shares, but it is not stated whether the dividend on these latter shares for 1915–16—7 per cent.—has yet been booked by the Allgemeine Elektricitäts Gesellschaft.

THE ROYAL METEOROLOGICAL SOCIETY.

THE monthly meeting of this society was held on Wednesday, the 20th instant, at the society's rooms, 70, Victoria-street, Westminster, Major H. G. Lyons, D.Sc., F.R.S., president, in the chair.

Mr. Carle Salter, assistant director of the British Rainfall Organisation, read a paper on "*The Measurement of the Rainfall Duration.*" Save for an article by Mr. Baldwin Latham in 1880, practically no attention appeared to have been paid to this subject till 1903, when Dr. H. B. Mill commenced collecting records for the British Isles, the number of which has grown till, in "British Rainfall, 1915," as many as 48 records were published. An examination of these records revealed certain inconsistencies, which were probably due to personal and instrumental causes. Two short series of observations made simultaneously with the "Halliwell Recorder" and the "Hyetograph," two of the most widely used types of self-recording rain gauge, showed a difference of about 10 per cent. between their respective indications. A rough comparison of all the available records suggested that the "Casella Recorder" gave generally the largest values and the "Beckley" the smallest. These differences appeared to be due principally to the varying degrees of sensitiveness of the instruments to very light rain, and the suggestion had been made that if rain of very low intensity were omitted from the records a closer approximation to homogeneity would be attained. An analysis of the "Halliwell" and "Hyetograph" records referred to, by the elimination of all rain at a less rate than 0.01 in. in 3 hours (or 0.1 mm. per hour) showed, however, that the original differences were not greatly reduced. The preliminary difficulties in standardising records of rainfall duration were analogous to those at first encountered in the case of records of duration of sunshine.

A paper by Professor H. H. Turner, F.R.S., entitled "*Discontinuities in Meteorological Phenomena, Third Note,*" was also read. In two previous papers it has been suggested that meteorological history is divided into definite chapters of an average length of 6¼ years, the separating dates being assigned according to a regular law. Further, that if these chapters are numbered consecutively, those with even numbers differ in certain essential respects from those with odd numbers. Some particular illustrations of these points have already been given, the elements studied being rainfall and temperature at different stations. The present paper gives the systematic analysis of 55 years' monthly rainfalls at 28 European stations. The division into alternating chapters is clearly brought out, and it is apparently possible to assign the separating dates from this material within a month. This precision is made possible by the existence of a five-monthly periodicity, for which some evidence was given in a former communication, but which is clearly established by the mass of evidence here submitted. The division into chapters has been connected in a former paper with the movements of the earth's axis. In the present paper some earthquake statistics are presented which appear to be favourable to this view.

LARGE THREE-PHASE GENERATORS.—Three-phase generators of 60,000 kilovolt-amperes, to be driven by steam turbine units of 50,000 kw., are being built in the shops of Siemens-Schuckert Werke and the A. E. G.; the steam turbines are constructed by the latter company. Two of these generators are under construction for the Rhenish-Westphalian Electricity Works; they are designed for 6,600 volts at 1,000 revolutions, and are combined with transformers which raise the tension to 110,000 volts.

OUR COAL OUTPUT.—The output of coal in the United Kingdom in the half-year ended June 30 was 128,135,000 tons, in round figures, as compared with 127,620,000 tons in the corresponding period of 1915, and 139,994,000 tons in the corresponding period of 1914. The war, by reducing the available supply of labour, has, accordingly, seriously curtailed our coal production, although there has been a slight rally this year as compared with 1915. The production of each coal-mining district to June 30 compared as follows with the corresponding output in the first half of 1915:—Northumberland, 5,520,000 tons, as against 5,471,000 tons; Durham, 16,779,000 tons, as against 16,720,000 tons; Yorkshire, 20,153,000 tons, as against 20,425,000 tons; Lancashire, Cheshire and North Wales, 12,466,000 tons, as against 12,620,000 tons; Derbyshire, Nottinghamshire and Leicestershire, 16,152,000 tons, as against 15,772,000 tons; Staffordshire, Shropshire, Worcestershire and Warwickshire, 10,001,000 tons, as against 10,030,000 tons; South Wales and Monmouthshire, 26,298,000 tons, as against 26,058,000 tons; other English districts, 2,783,000 tons, as against 2,672,000 tons; east of Scotland, 6,229,000 tons, as against 6,335,000 tons; west of Scotland, 11,707,000 tons, as against 11,476,000 tons; and Ireland, 47,000 tons, as against 41,000 tons. It is satisfactory to note that the small Irish production was not affected. Of the total output of 128,135,000 tons to June 30 this year, 64,271,000 tons were raised in the quarter ended March 31, as compared with 64,326,000 tons in the first quarter of 1915, and 72,765,000 tons in the first quarter of 1914. In the quarter ended June 30 the output was 63,864,000 tons, as compared with 63,294,000 tons in the corresponding quarter of 1915, and 67,229,000 tons in the corresponding quarter of 1914. There was a decrease of 0.4 per cent. in the number of persons employed this year, as compared with 1915; when the comparison is extended to 1914 we arrive at a decrease of 14.03 per cent., which represents the effect of the war upon the coal-mining labour market.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

WE give below a few data on several Colonial and foreign engineering projects taken from the *Board of Trade Journal*. Further information on these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

New Zealand.—H.M. Trade Commissioner in New Zealand, writing under date September 14, stated that fairly extensive harbour works are proposed to be carried out in Wellington and also in other parts of New Zealand, and that it is only because of the general tendency to economise on public works, and of the difficulty of obtaining material, that these are held up during the war. The country is in an extremely prosperous condition: exports have shown a great increase, and the shipping trade has been limited solely on account of the shortage of vessels. It may reasonably be supposed that, after the war, harbour facilities (many of which, in the minor ports particularly, are primitive) will have to be improved. It is, therefore, desirable that British firms interested should get into touch with the harbour authorities in New Zealand, especially at Wellington, Auckland, Port Chalmers, Lyttelton, Napier, Gisborne, Wanganui, Greymouth, Westport and New Plymouth. It would be well, also, for British firms to get into touch with the chief engineer of the railways and the chief engineer of the Public Works Department at Wellington.

Russia.—H.M. Commercial Attaché at Petrograd reports that the official *Bulletin of Laws* (Petrograd) publishes an Imperial Decree, dated September 18–October 1, authorising the city of Petrograd to conclude a bond loan of 20,000,000 roubles (about 2,111,000*l.* at par rate of exchange) of which 5,400,000 roubles (about 570,000*l.*) is to be devoted to water supply and canalisation works.

Peru.—According to *El Comerciante* (Buenos Aires), the Government of Peru has authorised Señor Alfredo Armand to carry out surveys for a narrow-gauge railway from a point on the Oroya–Huancayo line to the mining district of Jatunhuasi, province of Jauja. Plans of the proposed line must be presented to the Peruvian Department of Public Works within a year.

TUNGSTEN.—Dr. Dionys Kremer, in a dissertation accepted by the Technical High School, Aachen, describes experiments of preparing lumps of tungsten by alloying the powdered metal in the first instance with manganese. The alloy is then heated in the electric arc, where the manganese evaporates, leaving a metal of conchoidal fracture, containing 97 per cent. of tungsten, 1.6 of manganese and a little iron, silicon and carbon. Kremer could however, only obtain lumps of 50 grammes in this way; with larger masses of metal he had to apply the arc-heating so long that the tungsten became oxidised. As regards combinations of tungsten and other metals, he found that tungsten will not dissolve in calcium, magnesium, aluminium—all light metals, whilst the density of tungsten is 19.2—nor alloy with copper or tin; but it formed both solid solutions and compounds with the metals of the iron group and also with platinum. The process seems to be of academic rather than of practical interest.

OLD BRONZE CASTINGS.—The railway shops at Hanover are said to have been saving more than 5,000*l.* a year by modifying their treatment of old bronze scrap. To ensure that the bronze recast from scrap had the regulation strength of 25 kg. per square millimetre and elongation of 16 per cent., they had been obliged to add considerable quantities of fresh copper and tin to the old metal. Most of this fresh metal can be saved, according to the *Organ für Fortschritte des Eisenbahnwesens*, of September 1, 1916, by adding 0.3 per cent. of manganese copper and, further, about 1 per cent. of zinc to the scrap. The process is carried out as follows. The bronze scrap is fused in a crucible within an oil furnace. When the metal has become properly fluid, and has been well stirred, powdered charcoal is spread over the surface, and the temperature is raised to 1,300 deg. C. After renewed stirring the melt is poured into a red-hot ladle, into which is dropped, first the copper-manganese in small lumps, and then the zinc, always after good stirring. The zinc is itself preheated to 200 deg. C. The manganese acts as deoxidiser.

THE LATE MR. WILLIAM KING.—We regret to have to record the death, which occurred at his residence, 5, Beach Lawn, Waterloo, Liverpool, of Mr. William King, J.P. for Lancashire, and for 37 years (from 1867 to 1904) engineer to the Liverpool United Gas Light Company. Mr. King was 77 years of age at the time of his death. Several months ago he met with an accident in London, having slipped and fallen on the pavement; he was conveyed to the Charing Cross hospital and, later, was taken home, but had remained an invalid since. Mr. King's grandfather, the late Mr. Joseph King, was one of the original directors of the Liverpool Gas Light Company, and his name appears in the first local Gas Act, which was passed in 1818. His father, the late Mr. Alfred King, was engineer to the Liverpool United Gas Light Company from 1826 until the time of his death in 1867, in which latter year Mr. William King took up the duties of engineer to the company, a post which he held, as above stated, until 1904, when he retired. The deceased became a member of the Institution of Civil Engineers in May, 1874. He was deeply interested in a large number of local institutions and will be greatly missed by a wide circle of friends.

INDUSTRIAL NOTES.

The Director of the Department of Labour Statistics states in *The Board of Trade Labour Gazette* that nearly all the industries, especially those connected with war requirements, were fully employed in November, and in many cases were working overtime. Most of the essential trades would have been able to employ more labour if obtainable.

The changes reported as taking effect in November resulted in a net increase of about 32,500*l.* per week in the wages of about 350,000 workpeople. The largest bodies of workpeople affected were coal miners in Durham, woollen and worsted operatives in Yorkshire, and engineers in the London, Manchester and Leeds districts.

The number of disputes beginning in November was 21, and the total number of workpeople involved in all disputes in progress was 38,647, as compared with 18,697 in the previous month, and 20,502 in November, 1915. The estimated total aggregate duration of all disputes during the month was 155,000 working days, as compared with 106,600 in October, 1916, and 69,000 in November, 1915.

The average weekly number of vacancies notified to all Employment Exchanges for the four weeks ended November 10 was 41,113, as compared with 40,005 in the previous five weeks, and with 36,023 in the four weeks ended November 12, 1915. The average weekly number of vacancies filled for the same periods was 31,778, 30,413 and 26,177 respectively.

With reference to the food question in the United Kingdom, taking the country as a whole and making allowance for the relative importance of the various articles in working-class household expenditure, the average increase in retail prices of food between the beginning of the war and December 1 was 84 per cent., which is reduced to 78 per cent. if the increase in the duties on tea and sugar is deducted. The food prices in Berlin in October (later statistics are not available), as compared with those of July, 1914, showed an average increase of 109.4 per cent. In Vienna the average increase in food prices in November last compared with July, 1914, was 177 per cent.

The Minister of Munitions announces that 73 additional establishments have been declared controlled establishments, making the total 4,585.

Speaking in Parliament on Monday last, Sir George Cave, the Home Secretary, stated that the provision of labour was vital to-day for the conduct of the war; it was essential that misunderstandings between employers and workmen should not be allowed to interfere with the war, and the Government had thought it necessary to have a Minister who could give his whole energies to the work. There would be transferred to the Ministry of Labour the powers of the Board of Trade under the Conciliation Act, the Labour Exchange Act, the Trade Boards Act, the National Insurance (Unemployment) Acts, and part of the Munitions of War Act, 1915. The Ministry of Labour could not, he thought, come to an end at the end of the war; it had been created for war reasons, but there would be a good deal of work for it to do after the war.

The following letter was, on the 14th inst., addressed by the new Minister of Labour to the Trade Unions of the country:—

"For twenty years or more the Trade Union movement has insisted upon the institution of a Ministry of Labour. It is unnecessary to repeat the arguments which were put forward in support of this demand. It is for the moment sufficient to know that at last the demand has been conceded.

"The success of the department is vital both to employers and workmen; to be a success it must receive the whole-hearted support of employers as well as of the labour movement.

"The policy of the department will be one of impartial investigation with a view to deciding equitably upon conflicting claims. It will be readily understood that it is almost impossible for the Ministry either to investigate or conciliate successfully once a cessation of work has taken place.

"I therefore appeal very earnestly not only to the leaders of the workmen, but employers as well, to consult with me before a crisis is reached. In face of the gravity of the national situation, and the dangers resulting from any stoppage of work to the Allied cause, as well as to the lives and limbs of our sons and brothers who are maintaining the national interests by land and by sea, I feel confident that this appeal will not be in vain."

"(Signed) John Hodge."

Mr. D. Thomas Curtin stated in *The Times* of the 15th inst. that in Germany at the outbreak of war there were nearly 14,000,000 men between the ages of 18 and 45; of these, Germany normally employed in mines 600,000; metals, 800,000; transport, 650,000; agriculture, 3,000,000; clothing and food preparation, 1,000,000; making a total of 6,050,000. Of the 3,000,000 formerly engaged in agriculture, considerably less than 100,000 continue to be thus occupied, this work being now done by prisoners and women. Mine and metal work have kept from 60 to 70 per cent. of their men of military age. The number engaged in transport has been reduced to 300,000. Of the above total of 6,050,000, about 1,750,000 remain. From the building and allied trades at least 90 per cent. are in military uniform. The factors which have helped Germany in calling men to the colours are, first, the organisation of the women and, in the second place, the large number of prisoners in Germany and her sensible determination to make them work. Besides the prisoners taken in battle there also happen to be in Germany nearly 1,000,000 other prisoners; these are the Russian civilians who were caught in the German trap when it snapped suddenly tight in the summer of 1914. Another factor in the labour problem in Germany is the employment of the Poles.

Special representatives of German labour unions and employers' unions assembled together in order to discuss the necessary detailed measures of National Civil Service by working men. The Secretary of State, Helfferich, and the new war office chief, General Groener, were both present. The president of the main committee of the labour unions, in his opening speech, said: "To-day, representatives of the unions are assembled counting more than 4,000,000 members before the war. Working men know that our enemies want to destroy us and are doing all they can to carry out their menaces. We are ready to do anything in order to equip our brethren standing before the enemy so that they can match their enemies. Powerful forces are still slumbering in the country which will now be awakened." The Secretary of State, Helfferich, greeted the assembly in the name of the German Government and thanked all present who had come from all parts of Germany, had followed the call to National Service and declared their readiness to co-operate for the welfare of the country.

A dispute having arisen among the boilermakers in the port of Liverpool, the Minister of Labour addressed to them the following telegram:—

"I have assumed office to-day and regret that my first duty is to deal with a strike. No matter what grievances the men have it is impossible for me to deal with them until work be resumed. The day after work is resumed I will be prepared to meet a deputation and give them a full opportunity of stating the same, and upon the case they present act promptly and impartially. Let me impress the fact that a resumption of work must precede discussion."

On December 13 the Minister, in response to an invitation from the Mersey boilermakers to attend a meeting, telegraphed as follows:—

"With reference to your telegram asking me to attend a meeting of the Mersey boilermakers, I have already wired to the general secretary of the union pointing out how deeply I regret that my first official act is to deal with a strike. My appeal has been ignored, but I am still prepared to meet a deputation the day after work is resumed. To give workmen opportunity of doing so I will meantime defer other action. Do not impose upon me the alternative of having to exercise the compulsory powers of the Munitions Act."

The Minister of Labour also addressed the following telegram to the boilermakers on the 15th inst.:—

"The War Council endorse my action as being fair and reasonable; I give the men, the majority of whom I know must be opposed to a strike in the present crisis, and who have been misled by wrong influence, one last chance of resuming work Monday morning. In that event will meet deputation here Tuesday. Failure will result in proclamation taking full effect. Once more understand resumption of work must precede discussion. From this there will be no departure."

A meeting of the men was held on Saturday morning, at which they decided to resume full work on Monday morning, and to do urgent work if necessary over the week-end.

News received from Germany states that in honour of the centenary of the birthday of their ancestor, Werner von Siemens, the Siemens family established a fund of 1,000,000 marks for the construction of dwelling houses for employees and workmen. The Siemens and Halske Company, Limited, and the Siemens-Schuckert Works have added 1,000,000 each, so that the fund starts with 3,000,000 marks.

The Board of Trade announce that all arrangements for the holding of the British Industries Fair, 1917, are now complete, and forms of application for space are being issued by the Board. The fair will be held from February 26 to March 9, 1917. The growth of the fair has necessitated an increase of space, with the result that the fair will be held partly, as last year, in the Victoria and Albert Museum, placed at the disposal of the Board of Trade by the President of the Board of Education, and partly in the great hall and certain galleries in the Imperial Institute Building, which have been lent by the executive council of the Institute and by the University of London.

In view of the risk of interference with the output of munitions of war, it has not been possible to include in the fair certain trades which would otherwise have been invited to participate. The fair, therefore, will be confined to the same trades as were sanctioned by the Minister of Munitions last year. An important development, however, has taken place since last year in that the municipality of the city of Glasgow are organising a fair at Glasgow which will take place concurrently with the Board of Trade fair in London, and will include certain trades not comprised in the London fair. The Glasgow fair is being held under the auspices and with the support of the Board of Trade.

MONOMETER VERTICAL FURNACE.

On the opposite page we illustrate a new and interesting form of furnace which has recently been constructed by the Monometer Manufacturing Company, Limited, of Whitehouse-street, Aston, Birmingham, for a special purpose. In the furnace are four vertical tubes, which have to be uniformly heated throughout their entire length and kept within narrow margins of temperature. These tubes are arranged within a casing, and this is surrounded with a brick-lined furnace. Between the casing and the furnace are a number of rings of gas burners at different heights, so arranged as to give a uniform heating from bottom to top of the vertical tubes, which are about 9 ft. long, the diameter of the casing being about 3 ft.

Each ring of burners is provided with the Monometer thermostatic control, there being four of these instruments, which can be adjusted to give the temperature desired. In this way it is possible to be certain that every part of the tubes shall be heated uniformly and shall not differ from the determined temperature by more than a trifling degree.

Norwegian-American Shipbuilding.—The visit of Norwegian shipowners and financiers to America, for the purpose of placing large contracts for tonnage for Norwegian account, does not appear to have led to the desired result, several large American yards having been unable or unwilling to accept such contracts, on account of the comprehensive and increasing demand for tonnage within the United States. Only two large yards—at Delaware River, and Puget Sound in the State of Washington—are fairly busily employed for Norwegian account; but in those shipbuilding centres also several yards have refused to accept fresh Norwegian orders. The Pennsylvania Shipbuilding Company has at present 10 Norwegian vessels in hand, representing an aggregate sum of close upon 12,000,000 dols., and the firm of Pusey and Jones, Wilmington, has orders booked for a similar amount; but the New York Shipbuilding Company and William Cramp and Sons are stated to have refused all Norwegian orders. The Norwegian Commission have also met with refusals from the large yards in Newport, Bath and Quincy, in Massachusetts, the yards having stated that they are so fully employed with home orders as to be unable to accept any for foreign account.

Chemistry and Dyeing at the Bradford College.—The Technical College of the City of Bradford Education Committee especially provides for two day diploma courses, each of four years; three years may suffice in special cases. Students entering for these courses have to pass an entrance examination unless they come with a city council scholarship which is awarded by examination, or have passed the matriculation examination of the University of London or of the Northern Universities Board, or its equivalent. Students should have reached the age of 16 or 17 years; throughout the four college sessions, which extend from September to July, they have to attend on five days and a half per week. The first course is in industrial chemistry and dyeing; instruction in textiles, analyses of dyes and fibres, structure of yarns and fabrics come in the third year; experimental dyeing finishes with the third year: the fourth year is chiefly devoted to practical dye-house work, technical analysis and to physical chemistry and chemistry of dyestuffs; electrical engineering is also one of the subjects of the fourth year. The second course, in applied chemistry, also fits chemists for metallurgical works, gas engineering, oil and soap works, &c. In all the sessions instruction finishes at Whitsuntide, and the rest of the term is spent in visits to works and in practical work; this applies to all the four years, and a great many works of all kinds can thus be visited. There are various scholarships, also, for further studies; some of these are especially for students from the West Riding. Mr. Walter M. Gardner, M.Sc., F.I.C., is the principal of the college

MONOMETER VERTICAL HEATING FURNACE.

CONSTRUCTED BY THE MONOMETER MANUFACTURING COMPANY, ENGINEERS, BIRMINGHAM.

(*For Description, see opposite Page.*)

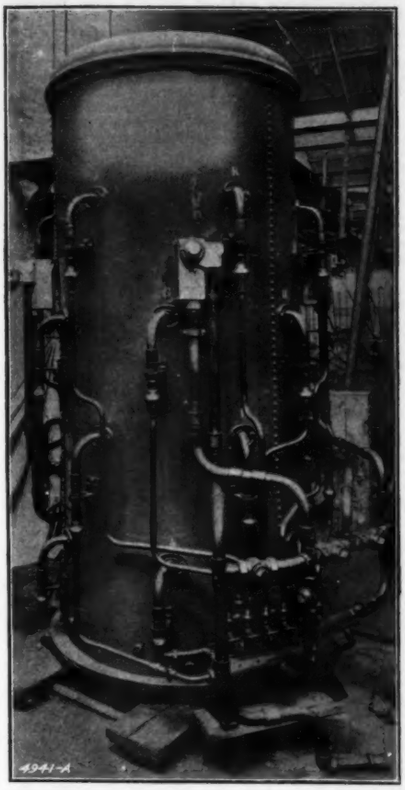
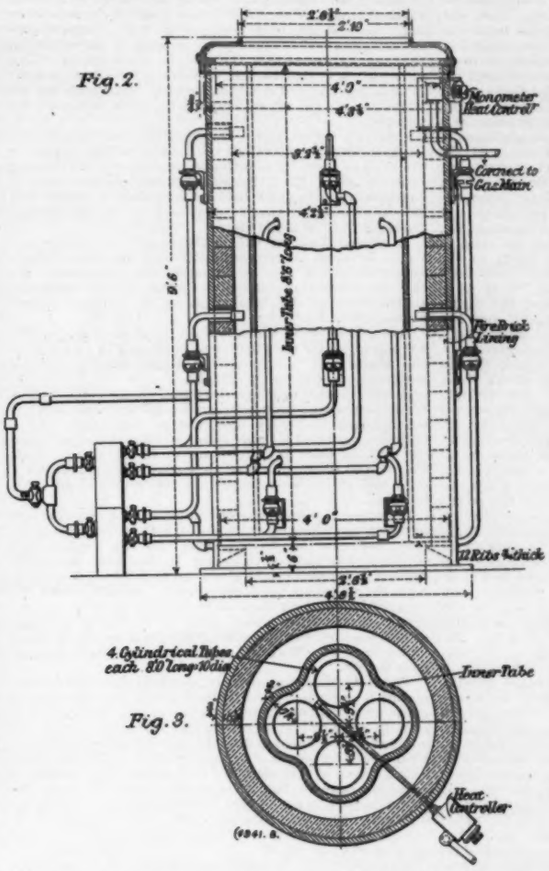
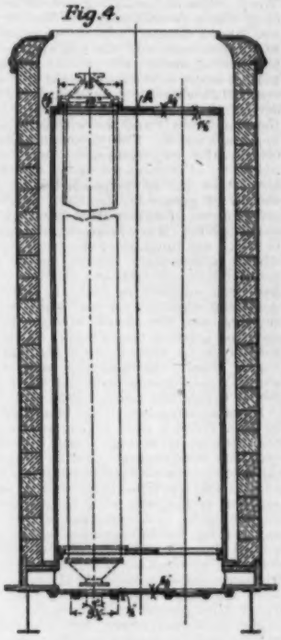
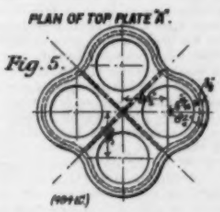


FIG. 1.







VARIABLE-SPEED GEARS FOR MOTOR ROAD VEHICLES.*

By ROBERT E. PHILLIPS, Member, of London.

Introduction.—The rapid development of road locomotion after its renaissance, brought about in this country by the passing of the Locomotive and Highways Act of 1896, may be attributed to three primary causes: (1) The introduction of the high-speed petrol motor, (2) the state of perfection to which variable-speed gearing has been brought, and (3) the employment of pneumatic tyres. Although the high-speed internal combustion engine has been dealt with in many papers read before this and other engineering societies, the author is not aware of any paper which has dealt exclusively and fully with the various mechanisms which have been and are employed to give a variable velocity ratio between the prime mover and the road wheels of motor road vehicles. In his opinion the bearing which the improvements in these mechanisms have had on the rapid development in road locomotion has not been fully recognised, and the perfection to which the variable-speed gear has been brought appears to have been overshadowed by the development of the prime mover.

The almost universal adoption of the high-speed petrol motor as the prime mover in motor road vehicles at once brought into prominence the importance of devices for enabling the ratio of speed between the prime mover and the road wheels of the vehicle to be varied, by reason of the fact that the speed of maximum torque of a petrol engine is practically at full power, and as the speed decreases so also does the torque. It may be remarked here in passing that, although the steam engine, on account of its extreme flexibility, has been, and still is, successfully used in motor road vehicles—more especially of the heavier class used for commercial purposes—it has been found advantageous even to fit such vehicles with a speed-reduction gear to meet the ever-varying exigencies of load and road. In the earlier motor road vehicles of the renaissance period variable speeds were obtained either by the use of a plurality of pulley and belt transmissions, or by the use of shaft-to-shaft gearing in which the wheels are engaged by a side movement—that is, in a direction parallel to the axis of the shafts. The former may be said to represent the German school, as instanced by the Benz and the Canstatt-Daimler vehicles, and the latter the French school, as instanced by the Panhard and the Peugeot vehicles.

Pulley and Belt Transmission Gear.—This is so well known that it is only necessary to state that it has been used with different-sized pulleys, with stepped pulleys, and with coned pulleys. Except for very light motor vehicles, such as motor bicycles and so-called cycle-cars, the use of this type of transmission is a thing of the past.

Shaft-to-shaft Gearing.—Although opposed to all mechanical principles, the side meshing type of spur-wheel gearing, in which the various trains of wheels are brought into engagement by "end-on" or clash engagement, has, by the perfection to which its design has been brought, by the high standard of workmanship employed in its manufacture, and by the use of the highest grade of materials, been developed into a completely satisfactory piece of mechanism. Although, from an engineer's point of view, it is theoretically an embodiment of everything that is wrong, in practice it has proved to be "not so bad as it looks on paper," and the fact that it has successfully held its own for nearly 20 years against many other gears which, theoretically, should give better results, is testified to by the fact that at least 90 per cent. of the motor road vehicles at present in use are fitted with this type of gear. It is, however, only fair to say at once that the position which the sliding type of gear now occupies is due to a very large extent to two factors: (1) That nothing like the same amount of attention has been directed to any other type of gear as has been brought to bear on this particular type, and (2) that the motors now used are of such a high horse-power that at least 75 per cent. of the running is now done on the direct drive. Mr. F. W. Lanchester—a member of this Institution—in his presidential address before the Institution of Automobile Engineers, tersely summed up the position of the sliding type of gear in these words: "The sliding type of change-speed gear has ceased to be objectionable to the extent that we have given up using it"—an opinion as true as it is concise.

Panhard Gear.—In the original gear of this type,* introduced about the year 1894 by the firm of Panhard and Levassor, of Paris, and commonly known as the Panhard gear, all the sliding wheels were mounted on a common element, so that it was necessary to run through the intermediate gears to get from the lowest to the highest gear, and *vice versa*, and consequently it is known as the "straight-through" type, in contradistinction to the "selective" type now in almost universal use.

Renault Gear.—About the year 1890 the firm of Renault Frères introduced a construction of change-speed gear and transmission gear which may justly be said to have revolutionised the design of the transmission mechanism of the modern motor road vehicle, as at least 90 per cent. of the motor road vehicles driven by internal combustion engines at present constructed embody one or other of the features of this gear. Instead of transmitting the power from the gear-box to the road wheels by means of a differential countershaft and chain gearing, the road wheels in the Renault system are mounted on a live differential axle which is coupled to the driven shaft of the gear-box by means of a longitudinally-arranged shaft, commonly called a propeller shaft.

The Renault gear not only provided for a direct drive between the driving and driven shafts—which is now considered a *sine qua non* in all gears of the sliding type, as it materially reduces both friction and noise—but it also rendered the lay-shafts not only idle but also quiescent during the direct drive. A further advantage of the Renault construction of gear is that the length of the gear-box can be reduced to a minimum, as there is no necessity for any clearance between the different gears, owing to the wheels of the different trains being entirely out of mesh before and when the sliding element forming the clutch coupling is moved. An example of this gear is given in the Appendix, Fig. 2, page 627.

Daimler Gear.—The advance that has been made in the side-meshing type of gearing will best be realised by comparing the original Panhard gearing, Fig. 1, page 627, with an up-to-date gearing as exemplified in the modern Daimler gear, which is described in the Appendix, Fig. 3, page 627.

The Daimler gear embodies two important features not to be found in the Panhard construction, namely, the placing of the driving and driven shafts of the gear in axial alignment, and the employment of more than one sliding element. The first of these two features enables the driving and driven shafts to be connected together by a direct couple, so that a through or direct drive from the engine to the transmission gearing can be obtained; and the other feature enables any desired gear to be obtained without running through any other gear. This type, which is known as the "selective"

* Paper read before the Institution of Mechanical Engineers on Friday, December 15, 1916.

* See Appendix, Fig. 1 (page 627).

type, has entirely superseded the "straight-through" type, as it not only reduces wear and tear on the teeth of the wheels, but enables the overall length of the gear-box to be materially shortened, which stiffens the shafts, and by removing the tendency to whip, which throws the gears out of pitch, not only materially increases the mechanical efficiency of the gear but also reduces noise. The junction of the driving and the driven shafts, and the spur wheels permanently gearing the driving shaft with the lay or countershaft are arranged at the front end of the gear-box, and the sliding element is mounted on the driven shaft. This allows the countershaft to be geared down in relation to the driving shaft, with the result that when the driving shaft is coupled direct to the driven shaft to obtain the direct or through drive, the countershaft and the wheels on it are rotating at a minimum speed. This was at one time thought to be of considerable importance, not only on account of the reduction of friction set up by the revolving parts, but also on account of the power lost by the churning up of the oil or grease in the box; but latterly, since the introduction of anti-friction bearings for the shafts and the use of thin oil as a lubricant, the opposite construction, in which the junction of the two shafts and the train of wheels permanently gearing one of said shafts to the countershaft are arranged at the back end of the box, has been adopted in order to reduce the noise to a minimum when the car is at a standstill with the engine running and the clutch between the engine and the gear-box is left in engagement, which is the usual condition of things when a car is making a temporary stop. Under these conditions the countershaft and all the wheels on it, together with the wheel on the driven shaft which drives the countershaft, are at a state of rest.

From a comparison of the two types of gear illustrated in Figs. 1 and 2, page 627, it will also be observed that each has an advantage over the other, with a corresponding disadvantage. In the former the power on all the speeds is transmitted through one pair of gear wheels, so that the frictional losses due to the gearing are the same on each speed, while in the latter type the power on one speed is direct, that is without going through any gearing, but on the other speeds the power is transmitted through two pairs of gear wheels, so that on all speeds other than the direct one there is twice as much frictional loss as in the type of gear illustrated by Fig. 1. This naturally directs attention to the fact that the direct drive should give the ratio of speed between the engine and road wheels best suited to each particular vehicle and the work it is called upon to perform. The general practice is to give the direct drive on the top or highest speed, and this is probably the best all-round practice for gears which give only three forward speeds; but when four forward speeds are provided the direct drive is sometimes on the third speed, the fourth speed—which in this case is a geared-up one—being only intended to be used under the most favourable running conditions.

The use of a plurality of sliding elements necessitates the use of a particular form of controlling mechanism, as each change of gear involves two distinct movements, one to pick up the particular rod controlling the sliding element giving the desired gear, and the other to impart the necessary movement to said controlling rod. This is effected by giving to the control lever two movements, first a lateral one in line with the axis of its pivot, and secondly a rocking one at right angles to said axis. This involves the use of a guide for the control lever having two longitudinal slots and a transverse connecting slot, hence the appellation "gate change" usually associated with this mechanism. This was first introduced into this country on the German Daimler cars known as the Mercedes, in the form shown in Figs. 4, 5 and 6 (Appendix, page 627), which is for a gear-box having three forward speeds and a reverse which are controlled by two sliding elements, one of which gives the top and second speed, and the other the first speed and the reverse.

Prevention of Wear on Teeth.—The prevention of undue wear and tear on the teeth of the wheels, due to the clash engagement, has been the desideratum of all designers of this type of gear, and the problem has been tackled in many different ways. The earliest method adopted was to keep the various trains of wheels constantly in mesh, one wheel of each train being loosely mounted on its shaft, and to provide independent sliding claw clutches for completing the driving couples between the wheels and their shafts. This construction had the defect that it seriously increased the overall length of the box and thereby increased both its weight and the cost of production. In a modification of this construction internal coupling devices were employed, but while these did not increase the length of the box they involved considerable complication. In another system the wheels on the countershaft were loosely mounted on said shaft, and an automatic driving couple was provided between each wheel and the shaft by means of a one-way clutch, so that the shaft could overrun the gear wheels, but said wheels could not overrun the shaft. The complications involved in this system were quite sufficient to condemn it.

Weller Gear.—According to another system the sliding wheels are mounted loosely on their shafts and are brought into mesh with the respective corresponding wheels of their trains before they become coupled to the shaft on which they are mounted. Such a gear is the Weller, Fig. 7 (Appendix, page 628). As this gear is probably as cheap, if not cheaper, to make than the usual pattern of this type of gear, owing to the absence of a square or splined shaft and a similar sliding element, it is difficult to understand why it has not been more universally adopted, as it undoubtedly affords considerable protection to the teeth of the wheels from damage by careless or ill-timed changing, and consequently would not only wear longer but would make for sweetness and quietness of running and ease of manipulation.

Dux Gear.—Further development along this line of construction brings us to the Dux gear, Fig. 8 (Appendix, page 628). In this gear the wheels of all the trains producing the forward speeds are in constant mesh, and the sliding wheels themselves form parts of positive clutches, the other parts taking the form of internal toothed rings. This construction enables the box to be kept very short, and produces a very compact and robust gear, but it appears to be open to the objection that at all speeds all the wheels are running. This gear-box is fitted to the Caledon commercial vehicle in this country, and has been exclusively adopted by the Paris General Omnibus Company for their public service vehicles.

Other Forms of Gear.—It would be quite impossible, without unduly extending the length of this paper, to attempt to describe all the various forms of this sliding type of gear. M. I. Rutishauser, an eminent French engineer, divides them into no less than 9 classes and 26 subdivisions. Other variations to which passing reference may be made are:—

A construction in which there are two permanent trains between the driving shaft and the countershaft, either of which can be brought into operation. By this means two speeds can be given to the secondary shaft, whereby the total number of indirect speeds obtainable is doubled.

A construction in which a plurality of secondary shafts are employed for the purpose of balancing the strains on the shafts and increasing the tooth surface without materially increasing the weight.

A construction in which the wheel on the countershaft of the permanent train between the driving shaft and the countershaft is loosely mounted on this shaft, and a clutch is provided for uncoupling it from this shaft when the driving shaft is coupled direct to the driven shaft to give the direct drive, so that during the direct drive only one of the gear wheels on the countershaft is in motion.

A further development of the latter is a construction in which the wheel on the countershaft of the permanent train between the driving shaft and the countershaft is mounted to slide on this shaft, so that when the direct drive is in operation said wheel can be drawn out of mesh with the wheel on the driving shaft; whereby both the countershaft and all the wheels on it are quiescent on the direct drive. This would seem to be the ideal form of this type of gear, but difficulties occur in side meshing two sets of wheels at the same time which this form of gear entails.

The common practice with the sliding type of gear is to mount it in an independent box, which in some cases is made as a complete unit with the engine, but which is usually arranged at a convenient distance behind the engine and is connected with the driving axle carrying the road wheels by means of a propeller-shaft. The enclosing and carrying of this shaft in a tube adapted to operate as a torque member has led some designers to make the gear-box part either of said torque tube or of the casing enclosing the rear driving axle. The objection to mounting the gear-box either on the casing of the rear driving axle or on the back end of the torque tube is that it increases the unsprung weight, but this is to some extent compensated for by the fact that the presence of a gear-box is considerably less evident to the occupants of a vehicle when it is located in this position than when it is mounted in the usual position on the frame of the chassis. This is probably due to the reduction of tremor owing to the better isolation of the gearing from the body of the vehicle. The drawback of increasing the unsprung weight is, however, considerably modified when the gear-box is carried on the forward end of the torque tube, which is a practice that has much to commend it.

When the gear-box is an independent unit it is of importance that it should be so mounted as to prevent any binding on the shafts due to distortion of the frame of the chassis. Either a spring suspension or a three-point suspension is usually adopted to this end. A convenient three-point suspension consists in carrying the gear-box fore and aft by means of trunnion bearings arranged concentrically with the driving and driven shafts, and preventing rotational movement of the box by connecting an arm, extending from the side of the box, to the frame by means of a link.

Silence in Gear-Box.—The great desideratum in a gear-box is now silence, as it was not until the internal combustion engine had been brought to a practical state of silence that the noises arising from the gear-box were fully realised. The noises from a gear-box may be divided into two classes. First, that produced by the running of the gears under load, which is more or less constant; and secondly, that produced by the clash engagement of the wheels or clutches, which is intermittent. While the former can be materially eliminated by careful design and workmanship, the latter must depend to some extent on the human element.

Dealing first with the noise produced by the running of the gears. It may be taken for granted, so far as present knowledge goes, that spur gearing of the sliding type cannot be made to run under load for any length of time without emitting a certain amount of noise, and that the problem of silent running depends to a very large extent on the care with which the gear is produced, and particularly so in relation to the teeth. To reduce the noise to a minimum, the following essentials must be observed: (1) The greatest care must be exercised in the production of the wheels, especially with regard to the teeth; (2) the box must have the necessary stiffness and its resonance be reduced as much as possible; (3) the shafts must be of ample diameter, be kept as short as possible, and be supported by a sufficiency of bearings so as to have a minimum of deflection; (4) the wheels must be small, in order to keep the peripheral speeds as low as possible; (5) the wheel centres must be absolutely accurate; (6) the wheels must be efficiently lubricated; (7) if ball-bearings are used, means must be provided to give some sort of a surface support in addition to the line contact of the balls in order to damp off the vibrations set up in the gear; and (8) single or double helical wheels must be used where possible.

As a certain amount of noise is inseparable from two spur wheels running together under a load, however well and accurately they may be made, another form of drive must be employed if a really silent gear-box is required. The London General Omnibus Company arrived at this conclusion by force of circumstances, as they could not reduce the noise in their omnibus chassis sufficiently to get it passed by Scotland Yard until they substituted a chain drive for the spur-wheel drive in their gear-boxes, and all of us are probably aware from actual experience how silent running these omnibuses are on all speeds.

Chain Drive.—Chain-drive gear-boxes were used as far back as 1901 by Brooke, of Lowestoft, but these boxes were not particularly quiet, as chains of the roller type were used, whereas the silence of the modern chain-drive gear-box is due to the use of chains of the "inverted tooth" type. In the gear-box used on the London General Omnibus Company's "B" type of chassis, an improved chain of the "inverted tooth" type, manufactured by the Coventry Chain Company, Limited, and known as the "Coventry Noiseless Chain," is employed, in which, for a given pitch, a rivet of larger diameter can be used, which not only increases the breaking load but also increases the wearing area of the rivet, the result being that a chain of but two-thirds the width of the standard pattern can be employed to transmit the same load. This firm has devoted considerable time and attention to the perfection of the chain-drive gear-box, and the problem they had to face was the finding of suitable wheels to run at a common centre distance to produce the desired speed ratios. That they have successfully tackled the problem is instanced by the large number of different designs of these gear-boxes that they have produced to meet the various demands of the automobile trade. One of these boxes is shown in Fig. 9 (Appendix, page 628).

In four-speed gear-boxes the additional speed is sometimes produced by an additional chain and pair of sprocket wheels, and sometimes by means of an additional spur wheel on the countershaft with which the spur wheel on the driven shaft employed for the reverse engages through an intermediate pinion.

In addition to the advantage of noiselessness, chain-drive gear-boxes have many other advantages, amongst which may be cited: (1) Flexibility of drive, which also operates as a safety valve and limits the destruction which a careless driver may cause by careless driving; (2) the obtaining of the speeds and the reverse with a minimum number of wheels; and (3) the ease with which chains can be replaced as compared with the replacement of a gear wheel.

The noise produced by the clash engagement of the gears arises chiefly from the difficulty of getting the teeth of the wheels into engagement, and this seems to depend essentially on the pitch of the teeth, on the peripheral speed of the wheels, on the shape of the engaging edges of the teeth, on the speed at which the wheels can be brought into engagement, and on the force resisting the inter-engagement of the teeth. The accepted practice is to use wheels of small diameter so as to keep the peripheral speed as low as possible, to keep the pitch of the teeth relatively small, and to round off the engaging edges or sides of the teeth. Although it is the common practice to round off the edges or engaging sides of the teeth, a much easier and quieter engagement results if the edges or engaging sides of the teeth instead of being rounded are chamfered or bevelled off, as this not only allows the teeth to become meshed to a greater depth before the drive comes on them, but also lessens the force resisting the complete meshing of the teeth, whereby the continued end-on movement necessary to bring the wheels completely into mesh is facilitated. This does not decrease the surface contact of the teeth subject to wear if the edges or engaging sides are chamfered or bevelled off on one side of the teeth only.

Changing of Gear.—Various devices have been introduced in the transmission gear between the clutch and the driving axle carrying the road wheels for the purpose of facilitating the changing of the gear, the most successful being a spring drive arranged between the clutch and the gear-box, and a secondary clutch arranged either in front of the gear-box to couple and uncouple the element of the main clutch carried by or coupled to the driving shaft of the gear-box, or at the rear of the gear-box to couple and uncouple the driven shaft of the gear-box and the propeller shaft of the transmission gear; but these devices are outside the ambit of this paper.

Automatic Gear-changing Devices.—Various systems have also been employed to make the changing of gears more or less automatic, so as to eliminate the human element. All such systems embody two essential features, one a method of pre-selecting the gears and the other the method of timing their change. The automatic gear-changing devices which have attained any measure of success may be divided into three types: (1) The mechanically operated; (2) the electrically operated; and (3) the pneumatically operated. The first type may be divided into two classes: (*a*) Those in which the clutch pedal releases a spring which brings the gears into mesh, this spring being compressed by hand at the time the selection of gear is made; and (*b*) those in which the clutch pedal operates the gear. In this latter arrangement no springs are employed, the mechanism simply transferring to the clutch pedal the operation which is usually performed by a hand lever.

The Linley device, described in the Appendix (Fig. 10, page 628), which has for some years been successfully employed on the Commer cars, is an example of the mechanical type.

In the electric system the pull on the sliding elements of the gear is effected by solenoids, which are brought into and out of action by means of switches suitably located so as to be operated by the driver of the vehicle, the arrangement being such that the switches merely operate as selectors for the particular gear desired, the actual closing of the energising circuit being completed by the movement of the clutch pedal. Although this system has not been employed in any vehicles manufactured in this country, it has been successfully employed in several cars manufactured in the United States and imported into this country, of which probably the best known is the Cadillac. Electricity would seem to be better adapted for the purpose than compressed air, as a source of current is available on most modern cars, at all events of the pleasure type, whereas a compressed-air system, besides requiring an air-compression plant, involves a far more complicated construction, and unless the apparatus necessary for working this system can be made considerably more simple than that which has already been evolved, or the compressed air can be also utilised for some other useful purpose on the car, it does not appear to be a commercially practical proposition. The electric current required to operate these electric change-gear systems is so small as to be practically negligible. In a test of one of these devices drawing its current from an 80 ampere-hour 12-volt battery, 134,000 changes of gear were made without exhausting the battery.

The absence of noise with a direct drive gear has led some designers to provide a direct drive on more than one speed. A common method of obtaining two direct drives is to employ two crown wheels—of different diameters—on the differential box and two bevel pinions on the propeller shaft, suitable clutches being provided for coupling one or other of said pinions on said shaft. This construction gives a direct drive at two different speeds, and when used with a gear-box has the additional advantage that it doubles the number of ratios of speed available. Some makers have adopted this system to obtain a direct drive on all speeds, but it has never been a commercial success, owing probably to the complication involved in providing suitable coupling devices for the driving pinions, to the fact that such a construction involves all the wheels of the gear constantly running, and to the increase of the unsprung weight on the back axle. One of the most successful of the direct-drive-on-all-speeds gear is that employed in the Sizaire-Naudin light car, Fig. 11 (Appendix, page 629). The Humpris gear is of a similar nature.

The number and ratios of the gears depend essentially on four factors: the power of the motor, the size of the road wheels, the weight of the vehicle laden, and the nature of the roads the vehicle has to traverse; but even when these four factors are constant a wide diversity of opinion exists as to both the best number and the best ratios. This much, however, may be said. The present tendency is to limit the number of gears to three and to reduce the gear ratio rather than increase it, and this latter probably arises from the desire to enable vehicles to travel on the direct drive for the greatest possible percentage of the distance travelled so as to avoid gear changing as much as possible.

The speed of the vehicle in relation to the speed of the engine is governed by the reduction in the final drive at the back axle, which is usually a single one. Some makers, however, employ a double reduction at the back axle, the merit of which—when used purely as a reduction gear—appears to be the ability to keep the wheels of each pair in the gear-box giving the various speeds of a more uniform size.

Before leaving this particular type of gear, which, as before stated, easily holds the first place in automobile construction, it will be well to tabulate both its advantages and its disadvantages. Its advantages are: (1) Simplicity of construction, (2) comparatively light in weight, (3) easy to understand and manipulate, and (4) ease and low cost with and at which worn parts can be renewed. Its disadvantages are: (1) Abnormal wear due to the clash engagement of the teeth of the wheels, (2) liability to considerable damage by bad driving, and (3) noise. What further improvement can be made in this type of gearing seems to be "in the lap of the gods," but as far as it is possible to forecast it would seem to lie in the direction of the use of some other or new metal or alloy for the box whereby increased stiffness and decreased resonance without increasing the weight will be attained, and in the all-round use of wheels having helical teeth.

(To be continued.)

APPENDIX.*

Panhard Gear.—In the early Panhard gear, Fig. 1, the primary or driving shaft V—capable of being coupled to the crankshaft of the motor by means of a friction clutch—and the secondary or driven shaft W are arranged in parallel relation to one another, the secondary or driven shaft being located above the primary or driving shaft. On the shaft V is mounted a sliding sleeve A, which carries four spur wheels, B, C, D and E, and on the shaft W are fixed four spur wheels, F, G, H and K, with which the sliding wheels B, C, D and E can be brought into engagement one by one. In the illustration the wheel B is shown in engagement with the wheel F, which gives the first or low speed. On moving the sleeve A to the left, the wheel B is disengaged from the wheel F and the wheel C is brought into engagement with the wheel G, which gives the second speed. Further movement to the left of the sleeve A brings first the wheel D into mesh with the wheel K, thus giving the third and fourth (or highest) speeds respectively. Motion is transmitted from the driven shaft W to a transversely arranged differential shaft L by bevel gearing, the motion of the shaft L being transmitted to the road wheels through chain gearing. Two bevel wheels are mounted on the shaft L, each of which is in permanent gear with the bevel wheel on the driven shaft W, a sliding clutch being provided for coupling one or other of said two bevel wheels to the shaft L for producing a drive either forwards or backwards.

The necessary motion is imparted to the sliding sleeve A by means of a fork M, which engages a groove in the sleeve A, this fork being operated by a pivoted hand lever through suitable connections, the lever being capable of being locked in the requisite positions to keep the various trains of wheels in engagement by trigger mechanism engaging with slots in a suitable quadrant.

Renault Gear.—In this gear, Fig. 2, the primary or driving shaft and the secondary or driven shaft are arranged in axial alignment, and a claw-coupling is provided between these shafts so that a direct drive, that is, not through any gearing, can be obtained. The various trains of wheels to effect the gear reductions are brought into mesh by an eccentric movement of the lay or countershafts after the manner of the back gear of a lathe. On the driving shaft V is mounted a sliding sleeve A, which carries a spur pinion B, and on the driven shaft W are fixed two spur pinions C and D, the latter of which has a sleeve E with which the sleeve A engages by means of a claw-clutch F, which is kept in engagement by the spring G and which is uncoupled by imparting a sliding movement to the sleeve A against the action of the spring G by means of a fork T, which engages a flange A^1 on the sleeve A. Located one on each side of the driving and driven shafts V and W are two countershafts X and X^1, which are eccentrically mounted in suitable bearings in the casing Y. On the countershaft X is mounted a sleeve H carrying two spur pinions J and K, and on the countershaft X^1 are mounted two sleeves L and M, which are coupled together by a claw-clutch N which is kept in engagement by the spring O. The sleeve L carries a spur pinion P and bevel pinion Q, and the other sleeve M carries a spur pinion R and bevel pinion S. On rotating one or other of the countershafts X or X^1 in a similar manner to the back gear of a lathe after the clutch F has been disengaged, either the pinions J and K can be meshed with the pinions B and D, or the pinions P and R

* [For convenience of reading we print herewith the portions of the appendix to which reference is made in the part of the paper appearing in our present issue.—ED. E.]

Fig. 1. DIAGRAM OF PANHARD GEAR.

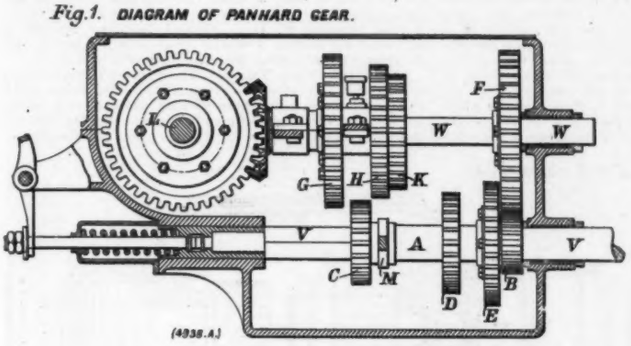


Fig. 2. DIAGRAM OF RENAULT GEAR

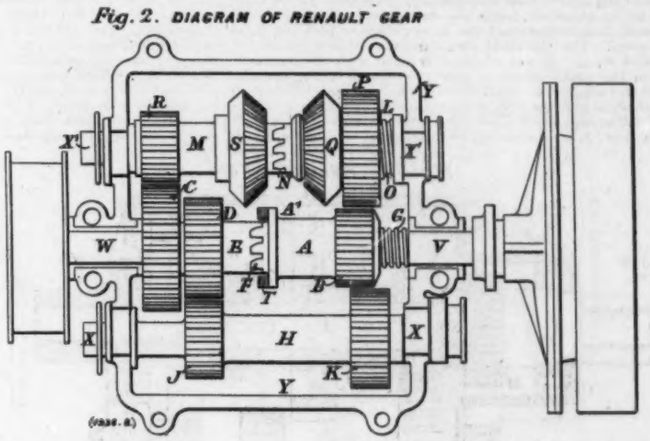


DIAGRAM OF MERCEDES CONTROL.

Fig. 4.

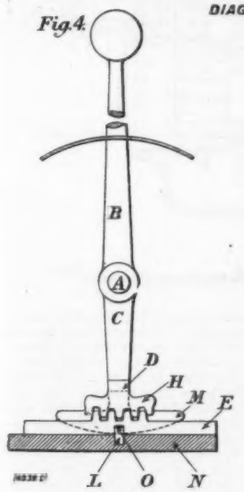


Fig. 5.

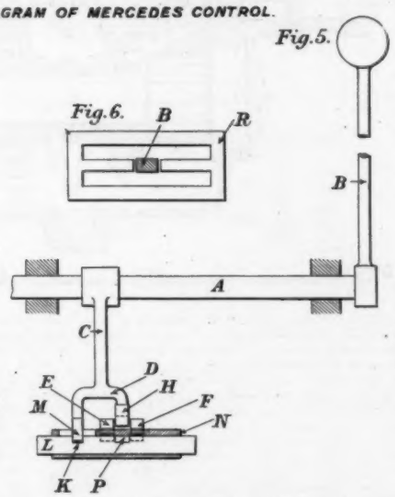
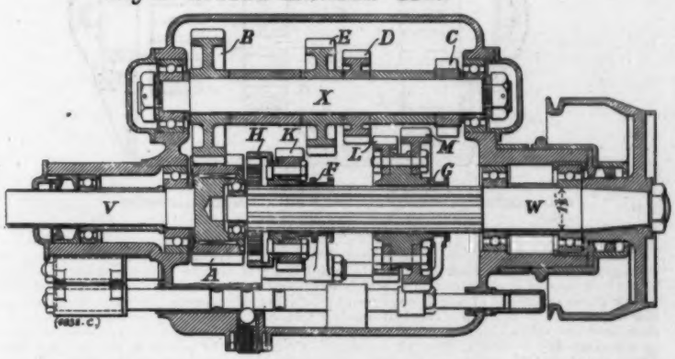


Fig. 6.

Fig. 3. MODERN DAIMLER GEAR



can be meshed with the pinions B and C, thus giving the first or second speeds.

The third or top speed, which is a direct drive, is obtained when the pinions on the countershafts are out of engagement with those on the driving and driven shafts and the clutch F is re-engaged. The reverse is obtained by separating the bevel pinions Q and S by means of a wedge action and introducing a third bevel pinion to mesh with these bevel pinions, at the same time uncoupling the clutch F and throwing the pinions P and R into engagement with the pinions B and C.

Modern Daimler Gear.—In this gear, Fig. 3, the front end of the driven shaft W is journalled in the rear end of the driving shaft V, on which is fixed the permanent driving spur pinion A, which is in constant mesh with a spur pinion B on the countershaft X. This countershaft also carries other spur pinions C, D and E. The driven shaft W is splined, and on it are mounted two sliding sleeves F and G, the former carrying both an internally-toothed wheel H and a spur pinion K. The internally-toothed wheel H, by engaging with the pinion A, forms a direct-driving couple between the driving shaft V and the driven shaft W, and gives the fourth or top speed, and the spur pinion K, by engaging with the pinion E on the countershaft, forms the driving connection between said countershaft and the driven shaft to give the third speed. The sleeve G also carries two spur pinions L and M, the former adapted to mesh with the pinion D on the countershaft to give the second speed, and the latter adapted to mesh with the pinion C on said countershaft to give the first or lowest speed.

Mercedes Control.—In this control, Figs. 4, 5 and 6, a shaft A is so mounted as to be capable of having both a fore and aft rocking movement and a transverse sliding movement imparted to it by the hand lever B. This shaft carries a selector arm C which terminates in a fork D, one element of which engages one or other of the rods E and F through a toothed quadrant H and a rack, and the other element of which engages a slot K in a locking key or bolt L through a plain quadrant M. The rods E and F, which engage the sliding elements of the gear by means of the usual forks, are mounted to slide in a suitable guide N, in which the locking key or bolt L is mounted and arranged to slide. The plain quadrant M, by reason of its permanent engagement with the slot K in the key or bolt L, is free to move in respect of this key or bolt when the shaft A is rocked, and to impart a corresponding relative movement to this key or bolt when the shaft A is moved axially. In the underside of each of the rods E and F is a slot O with which the key or bolt L engages, and in this key or bolt is a second slot P, which will allow either of the rods E or F to pass across it when they are brought into line with it by the transverse movement of the selector arm C. It will be seen that, by imparting an axial movement to the shaft A, the toothed quadrant can be moved out of its central position—in which it can have no rocking movement by reason of its engagement with the central bar of the "gate" guide—and can be engaged with one or other of the controlling rods E and F, at which time the slot P in the key or bolt L is so positioned as to allow the rod with which the toothed quadrant is engaged to slide in its bearing—through the key L—on motion being imparted to it by the toothed quadrant H by reason of the rocking motion imparted to the shaft A. The gate R for this mechanism is illustrated in Fig. 6, the hand lever B being shown in its central position, in which position, as shown in Fig. 5, the toothed quadrant H is out of engagement with either of the rods E and F, and these rods are positively locked against movement by the key or bolt L. If the hand lever is moved into one or other of the slots of the gate the selector arm becomes engaged with one or other of the controlling rods, and on a fore or aft movement being imparted to the hand lever, the sliding sleeve in the gear-box is moved in one or other direction to engage one or other of two trains of wheels. When there are four speeds and a reverse, the two sliding elements give the top and third speeds and the second and first speeds respectively, and the reverse is obtained either by means of a separate sliding element with an independent pick-up, or by running through the first speed.

Instead of using a positive lock for the controlling rods, automatic spring-controlled catches are often employed. A common form is a small sphere held up by a spring and adapted to engage with grooves turned in the controlling rod. Such a device is shown in the illustration of the Daimler gear-box, Fig. 3. The most up-to-date practice is to mount the gear-changing mechanism on the gear-box instead of on the frame of the vehicle, so as to avoid the possibility of any binding taking place due to distortion of the frame.

Weller Gear.—In this gear, Fig. 7, a sleeve A carrying two spur pinions B and C, and having claws D at each end, is mounted on the driving shaft V so that it is free both to slide and rotate thereon. On the driven shaft W, which is hollow and fits over the end of the driving shaft, is fixed a spur pinion E having claws F on its inner side. On the shaft V is also mounted a sleeve G, which is free to slide thereon, but which has no independent rotary movement. This sleeve is provided with claws H at each end, whereby it can be coupled either to the sleeve A carrying the spur pinions B and C by means of the claws D and H, or to the spur pinion E on the driven shaft by means of the claws F and H. On the countershaft X are fixed three spur pistons J, K and L, the former of which is in constant mesh with the pinion E on the driven shaft. On the driving shaft is a fixed spur pinion M for the reverse which is provided on its end opposite the sleeve A with claws N adapted to engage with the claws D on the adjacent end of said sleeve. If the sleeve G is moved to the right until it engages the spur pinion E, the driven shaft is coupled to the driving shaft, thereby giving a direct through drive, which is the top gear. If the sliding sleeve A is moved to the right after the sleeve G has been withdrawn from engagement with the pinion E, the pinion C first becomes meshed with the pinion K on the countershaft, and subsequently becomes engaged with the sleeve G, the effect of which is to couple the pinion C to the driving shaft and give the second speed through the wheels C, K, J and E. The dot-and-dash line shows how the pinion C is engaged with the pinion K before it engages the sleeve G, thus ensuring the safety of the teeth of the pinions at the moment of the couple of the pinion C with the driving shaft. If the sleeve A is moved to the left the pinion B first engages the pinion L on the countershaft, and subsequently becomes coupled to the driving shaft by the engagement of the sleeve A with the pinion M. Within the boss of the sleeve A is a friction ring O, the function of which is to cause the sleeve to rotate with the shaft when the sleeve is in its central or free position, whereby the wear between the sleeve and the shaft is reduced to a minimum, as the only movement between these two parts is at the moment of engagement of the first and second-speed trains. The reverse is obtained by bringing an intermediate pinion mounted on an independent shaft—not shown in the illustration—into engagement with both the pinion M and the pin on L when the sleeve A is in its central or free position.

Duz Gear.—In this gear, Fig. 8, a spur pinion A is so mounted on the driving shaft V as to have free relative rotary movement thereon, and is in constant mesh with a spur pinion B, fixed on one end of the countershaft X. On the other end of the countershaft is fixed a spur pinion C, which is in constant mesh with a spur pinion D, fixed on the driven shaft W. On the driving shaft, which is splined to receive it, is a sliding sleeve E, which carries two spur pinions F and G, and on the countershaft are, loosely mounted, two spur pinions H and J, the former of which is in constant mesh with the pinion F, and the latter in constant mesh with the pinion G. Each of the pinions A and D has an internal ring of teeth with which the teeth of the pinions F and G respectively engage when the sleeve E is moved to the right or left, and each of the pinions H and J has an internal ring of teeth which engages with the teeth of the pinions B and C respectively when the pinions are moved to the right or to the left. Motion is imparted to the sleeve E by means of the usual fork K, and motion is imparted to the two pinions H and J by a fork L, which engages the bosses of both of these pinions, so that, although the pinions have free relative rotary movement, they are constrained to move together axially.

The top or direct drive is obtained by engaging the pinion G with the internal teeth of the pinion D, thereby locking the driving shaft to the driven shaft. The third speed is obtained by sliding the sleeve E until the pinion F engages the internal teeth of the pinion A, so that the drive is transmitted through F–A, B, C and D. The second speed is obtained by sliding the two pinions H and J until the internal teeth of the pinion J engage the pinion C, so that the drive is transmitted through G, J, C and D. The first speed is obtained by sliding the pinions H and J until the internal teeth of the pinion H engage the pinion B, so that the drive is transmitted through F, H–B, C and D. The reverse is obtained by sliding a double gear—not shown in the illustration—into mesh with the pinions D and H.

Chain Gear-Box.—This box, Fig. 9, gives three forward speeds and a reverse, the forward speeds, other than the direct drive, being produced by sprocket and chain wheels, and the reverse by spur wheels. On the driving shaft V is fixed a sprocket wheel A, and on the driven shaft W are two loosely mounted sprocket wheels B and C. On the countershaft X are fixed three sprocket wheels D, E and F. On the inner end of the driving shaft, which forms the spigot for the inner end of the driven shaft, is a collar G, having internal teeth H, which forms part of a claw-clutch. Between this collar G and the sprocket wheel B is a sliding sleeve J, which carries two rows of teeth L and M forming parts of claw-clutches. The sprocket wheels A and D, B and E, and C and F are coupled by means of chains of the Coventry "noiseless" inverted-tooth type. By moving the sleeve J to the left the teeth L engage the teeth H, whereby the driven shaft is coupled to the driving shaft, which gives the direct and top drive. By sliding the sleeve J to the right the teeth M engage an internal row of teeth N carried by the sprocket wheel B, whereby the sprocket wheel is coupled to the driven shaft, which gives the second speed through the wheels A, D, E and B. On the driven shaft beyond the sprocket wheel C is a sliding sleeve O, on one end of which are teeth P and on the other end of which is a spur wheel Q. By moving the sleeve O to the left the teeth P engage an internal row of teeth R on the sprocket wheel C, whereby the latter is coupled to the driven shaft, which gives the first speed through the wheels A, D, F and C. By moving the sleeve O to the right the spur wheel Q is brought into mesh with a spur pinion S on the countershaft, whereby the reverse is obtained through the wheels, A, D, S and Q. It will be seen that, as when two shafts are coupled together by chain and sprocket-wheel gearing they both rotate in the same direction, the reverse can be obtained by the use of two spur wheels only without the use of an intermediate wheel.

Linley Automatic Control.—In this control, Fig. 10, a spur pinion A is loosely mounted on the driving shaft V—which is arranged in axial alignment with the driven shaft W—and is constantly in mesh with a spur pinion B fixed on the countershaft X. On the driven shaft are loosely mounted three spur pinions C, D, and E, each of which is provided on one side with claw-teeth, and two of which, C and D, are respectively constantly in mesh with pinions F and G on the countershaft. Mounted on the squared end V^1 of the driving shaft V is a sliding double claw-clutch H, which, if moved to the left, engages with teeth carried by the pinion A, thereby locking the pinion to the driving shaft and if moved

Fig. 7. WELLER GEAR

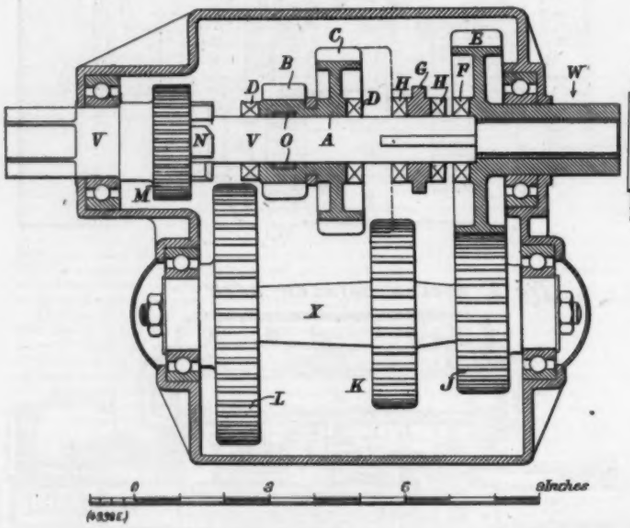
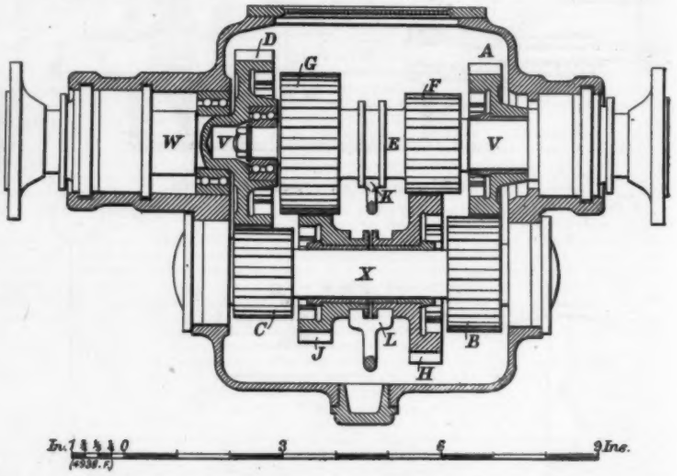


Fig. 8. DUX GEAR.



to the right engages with teeth carried by a collar J fixed on the driven shaft and forms the spigot for supporting the bearing for the inner end of the driving shaft, thereby locking the driving shaft direct to the driven shaft and producing the direct drive and top speed. On the squared parts of the driven shaft between the wheels C and D and D and E are mounted two other sliding claw-clutches K and L, the former of which, if moved to the left, couples the pinion C to the driven shaft for producing the second speed, and if moved to the right couples the pinion D to the driven shaft for producing the first speed. The other clutch L, if moved to the right, locks the pinion E to the driven shaft for producing the reverse through an intermediate pinion, not shown, which gears with both E and G. Mounted parallel with the driving and driven shafts is a camshaft M, which is rotated by the operation of the change-speed lever through suitable mechanism. This shaft carries three cams, N, O and P. With each of the cams N and O two rollers, carried by two spring-controlled levers Q of the fly-to-centre type, engage, and with the cam P one spring-controlled lever Q^1 engages. The springs controlling these levers are not shown in the illustration, for the sake of distinctness. Between each of the pair of levers Q is an arm R, forming part of the swinging fork S, by means of which each of the sliding clutches H and K is shifted, and the lever Q^1 is carried by a sleeve which carries the swinging fork S by which the sliding clutch L is shifted.

When the change-speed lever is in its neutral position the peripheries of the cams are all parallel, so that the fly-to-centre levers are lying dormant and the clutches are all disengaged. The claws of the clutches and the parts with which they engage are undercut, so that they remain in engagement even against the pressure of the spring of the fly-to-centre levers so long as a driving pressure is on them, but when this pressure is released, either by de-clutching the engine or by throttling the engine down so as to remove the driving effort temporarily, the spring operates to cause one of the clutches to become operative, either alone or at the same time that the other clutch becomes inoperative.

The operation of changing speed is as follows: when the change-speed lever is brought from the neutral notch into the first-speed notch, it rotates the camshaft for about one-fifth of a turn. This causes the cam N to throw over one of the pair of fly-to-centre levers Q, thereby putting tension on the spring which controls these levers, with the result that the moment that the claws of the clutch H come opposite to those of the pinion A the spring acting through the arm R causes them to engage automatically, thereby locking the pinion A to the driving shaft. At the same time the movement of the second cam O has performed a corresponding operation on the pair of fly-to-centre levers Q controlling the clutch K, and the spring acting through the arm R causes this clutch to engage with the first speed pinion D, thereby locking it to the driven shaft and completing the train A, B, G and D for producing the first speed.

When the change-speed lever is moved into the second-speed notch, which operates to rotate the camshaft through a further part of its revolution, no further motion is communicated to the levers Q controlling the clutch H, so that the clutch remains engaged with the pinion A. The second cam O, however, operates to transfer the tension of the spring of the pair of fly-to-centre levers controlling the clutch K in the opposite direction, so that when the driving strain is released the spring operates through the arm R to throw the clutch K out of engagement with the first-speed pinion D and into engagement with the second-speed pinion C.

On putting the change-speed lever into the third-speed notch the camshaft is again partially rotated, which causes the cam O to operate to put tension on the spring of the pair of fly-to-centre levers Q controlling the clutch K, so that, when the driving strain is released, the spring operates through the arm R to draw the clutch K out of engagement with the pinion C, and causes the cam N at the same time to operate to transfer the tension of the spring of the fly-to-centre levers Q controlling the clutch H in the opposite direction, so that, when the driving strain is released, this spring operates through the arm R to throw the clutch H out of engagement with the pinion A and into engagement with the claws of the collar J on the driven shaft, thus coupling the driving and driven shafts together and giving the third or top speed with a direct drive.

To obtain the reverse, the change-speed lever is moved into the reverse notch, which causes the cam N to operate to engage the clutch H with the pinion A, and at the same time causes the cam P to operate to allow the clutch L to be pulled over—by a spring not shown in the illustration—to engage with the reverse pinion E, which is driven from the pinion G on the countershaft through an intermediate pinion, which is also not shown.

It will be seen that the reason that the gear does not change immediately on pulling over the change-speed lever is that the clutches cannot disengage themselves while under load. The pulling over of the lever simply compresses a spring, which cannot move the clutches owing to the pressure on their engaging claws. When this pressure is removed by de-clutching or by releasing the driving effort, the spring which has been compressed asserts itself and changes the gear. The gear changing can only be automatically effected when the engine is actually driving the car, so that if it becomes necessary to change the gear when the car is over-running the engine, it must be effected in the usual way, namely, by de-clutching before actuating the change-speed lever.

Sizaire-Naudin Gear.—In this gear, Fig. 11, a crown wheel A is mounted on the differential casing U of the live back axle Z, and on an extension V of the propeller shaft are three spur pinions B, C and D, which give the three forward speeds by engagement with the crown wheel A. The driving shaft V is mounted in bearings E carried by a frame F, which is so mounted on a longitudinally-arranged shaft located under the back end of the driving shaft—not visible in the illustration, which is a view in plan—that it is free to rock transversely and move longitudinally in relation to the crown wheel A, for the purpose of bringing one or other of the spur pinions B, C and D into engagement with the wheel, the driving shaft being so connected to the propeller shaft of the engine as to allow of the required longitudinal movement, and the usual universal joint at the front end of the propeller shaft allowing the transverse movement. On a shaft H, located at the side of the driving shaft, is a grooved cam M, which is so shaped that rotation of the shaft produces the necessary compound rocking and sliding movement of the frame F to bring the pinions B, C and D successively into engagement with the crown wheel A.

To produce the reverse the driving shaft is moved longitudinally in relation to the frame E by means of an independent fork J to bring the first-speed pinion B into mesh with a pinion K mounted on an independent shaft L, after which the frame E is moved by the action of the shaft H and the cam M to bring the pinion K into mesh with the crown wheel A, its intermediate position between the spur wheel B and the crown wheel A giving the reverse motion to the crown wheel.

(To be continued.)

Fig. 9. CHAIN GEAR-BOX.

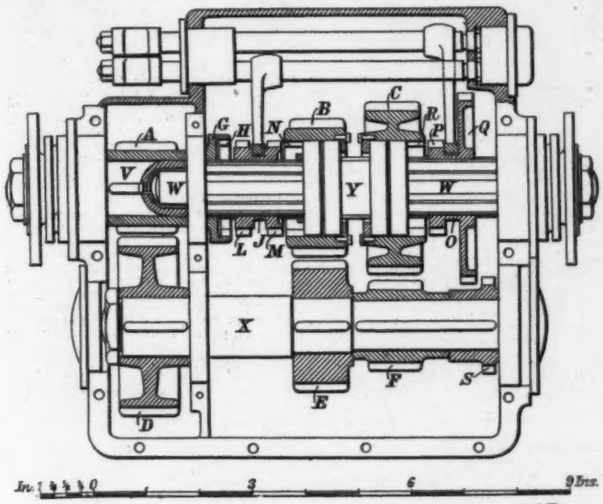


Fig. 10. LINLEY AUTOMATIC CONTROL

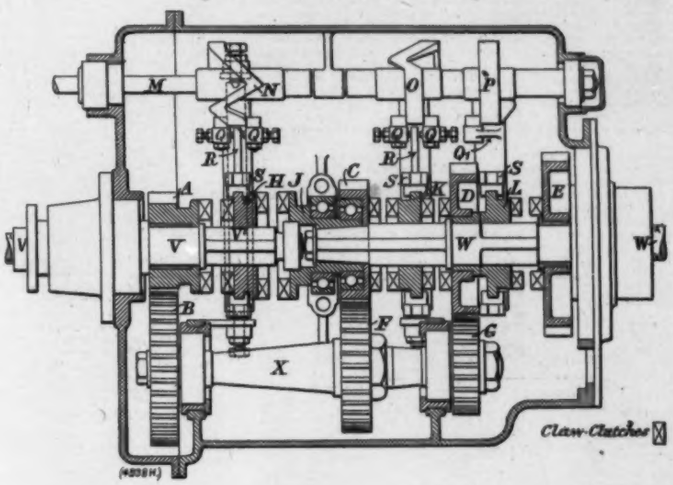
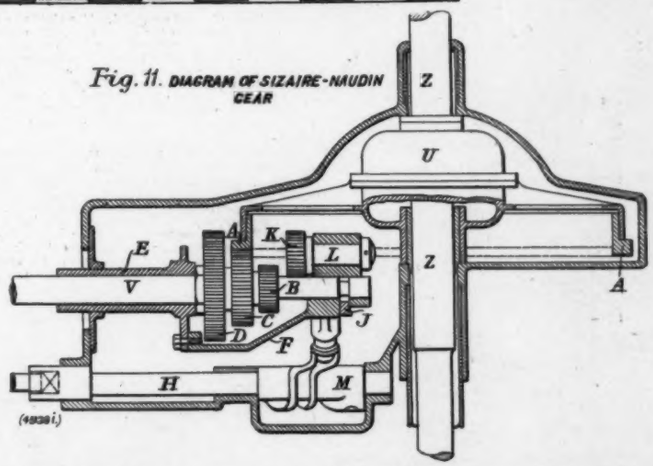


Fig. 11. DIAGRAM OF SIZAIRE-NAUDIN GEAR



SOUTH AFRICAN GOLD MINING.—The output of gold in the Witwatersrand district in 1915-16 was 8,971,582 fine oz., obtained from 28,754,982 tons of ore crushed. The working profit realised was 11,860,000*l.*, in round figures. In 1914-15 the production was 8,394,573 fine oz., obtained from 27,283,176 tons of ore crushed. The profit realised was 11,820,000*l.* in round figures. There has been a slight decrease this year in the output of the mines outside the Witwatersrand area; but taking the Transvaal as a whole, the ore milled showed an increase of 1,510,310 tons, the increase in the gold output being 571,762 fine oz., valued at 2,428,691*l.*

AMERICAN PATENTS.—With the growth of population in the United States the number of patents issued has also greatly increased. In 1850 the number of patents issued was 993; in 1860, 4,778; in 1870, 13,333; in 1880, 13,947; in 1890, 26,292; in 1900, 26,499; in 1910, 35,930; in 1911, 34,084; in 1912, 37,731; in 1913, 35,788; in 1914, 41,850; and in 1915, 44,934. These progressive totals show that the Americans have given free scope to their inventive instincts. The number of applications for patents shows that only about two-thirds have been admitted during the last 20 years. The applications numbered 40,680 in 1895; in 1905 the total had risen to 54,971; and in 1915 it stood at 70,069. The American patent office yields respectable profits, the net receipts for the five years ended with 1915, inclusive, having been as follow:—1911, 65,698 dols.; 1912, 79,133 dols.; 1913, 137,035 dols.; 1914, 251,123 dols.; and 1915, 237,331 dols.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

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ELECTRICAL APPARATUS.

13,568/15. T. F. Wall, Birmingham. Minimising Sparking. (3 *Figs.*) September 24, 1915.—It can be shown that by suitably choosing the moment at which an alternating current circuit is closed the current may be caused to pass through its zero value at the moment when the applied potential difference passes through its zero value. This moment will then be a favourable time for opening the circuit so that minimum sparking takes place at opening. A is an alternator supplying a circuit containing inductance *b* and capacity *c*. An insulated disc *e*, driven synchronously with the alternator, carries a metal segment *f*, which segment can bridge two brushes *g* at a break in the circuit. It may be convenient in some cases to provide an adjustable resistance *d* in the circuit for the purpose of obtaining the correct coincidence of the current and applied potential difference waves when switching open the circuit. The length of the segment *f* is such that the brushes may be set to make and break the circuit at the correct instants. A switch is indicated by *h*. A practical application of the invention as applied to wireless telegraphy circuits is shown in Fig. 2. In addition to the contact *f* there is a tapping key *m* which also forms the armature of two electro-magnets *l* and *k*. The electro-magnet *k* is in series with the

Fig. 1.

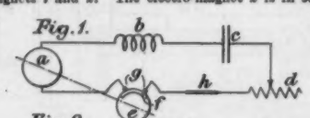
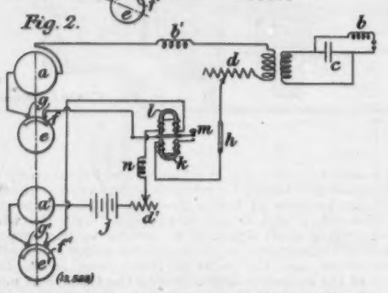


Fig. 2.



primary main circuit and is adapted to hold the switch *m* in the closed position after the circuit has been made until the circuit is interrupted by the contact maker *f*. The electro-magnet *l* is in series with an alternator *a*1 provided with a synchronously rotating disc *e*1 and contact segment *f*1 acting in conjunction with the brushes *g*1. The inductance *b*1 represents the whole of the inductance in the magnetically-coupled circuit of alternator *a* and condenser *c*. The inductance *b*1 may be variable in order to bring this magnetically coupled circuit into resonance with the alternator frequency. A battery *j* and adjustable resistance *d*1 are in series with the electro-magnet *l*, and also an extra inductance *n* may be used. The object of the electro-magnet *l* is to prevent the main circuit being closed when the segment *f* bridges the brushes *g*, and only allows the circuit to be closed when the brushes *g* are not electrically bridged by the segment *f*, thus allowing the segment *f* to control the closing of the circuit. The operation of the electro-magnet *l* may be made most favourable by setting the segment *f*1 correctly with reference to the segment *f*, and, if necessary, using for the alternator *a*1 a machine with a slightly smaller number of poles than the alternator *a* possesses. (*Accepted October* 11, 1916.)

13,904/15. The British Thomson-Houston Company, Limited, London. (*General Electric Company, Schenectady, New York, U.S.A.*). **High-Frequency Alternators.** (6 *Figs.*) September 30, 1915.—5 represents the stator frame of the machine, into which are screw-threaded a pair of ring-shaped members 6—6. Each of these members carries a circumferentially laminated ring 7 of magnetic material clamped between two

Fig. 1.

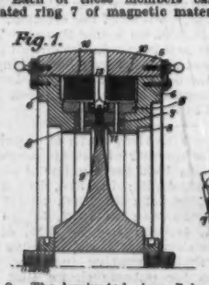


Fig. 2.

rings 8. The laminated rings 7 have opposite faces lying in adjacent radial planes. Between these rings extends the peripheral portion of the rotor, which comprises a solid magetic inductor 9. Two exciting windings 10 are mounted in the stator of the machine. The magnetic circuit of the exciting windings 10 includes the laminated rings 7, the periphery of the inductor 9, the stator frame 5, and the ring-shaped members 8. The air gaps between the inductor 9 and the laminated rings 7 lie in parallel radial planes. The inductor 9 is slotted near its periphery so as to form magnetic poles. In order to avoid excessive windage at the high speed at which the inductor is designed to operate, the slots in the inductor periphery are filled with solid non-magnetic blocks 11. The blocks are mounted so as to fill the slots flush with the radial sides of the inductor. The armature winding 13 is carried in slots in the faces of the laminated rings 7 adjacent the inductor poles. This armature winding is carried zig-zag through the slots of the laminated ring, as clearly shown in Fig. 2. The widths of the stator teeth and inductor poles are so proportioned that as the inductor rotates the number of rotor poles opposite any stator tooth alternates between $\frac{n+1}{2}$ and $\frac{n-1}{2}$ where *n* is any odd number greater than unity. (*Accepted October* 11, 1916.)

100,788. Firm Aktiengesellschaft Brown, Boveri and Cie., Baden, Switzerland. Pressure Regulators. (4 *Figs.*) June 20, 1915.—This invention has for its object an astatic carbon pressure regulator. Fig. 1 shows apparatus of the simplest type comprising a column of carbon plates *k* and a turning magnet *m*. The pressure point *d* upon curved lever *h*, the point of a knife-edge support *p* of the sector *s*, and the axis of rotation *c* of the armature *a* of the turning magnet, are all situated in one straight line, so that the force of the spring *f* has no moment or leverage in relation to the axis of rotation *c*.

Fig. 1.

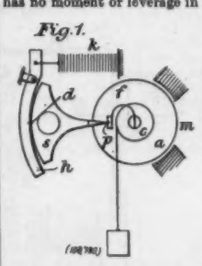
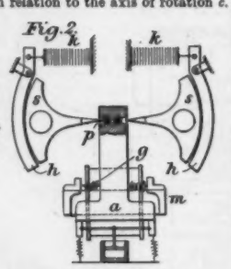


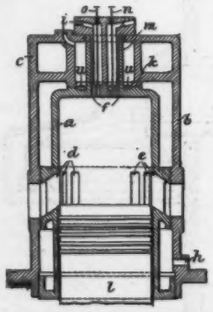
Fig. 2.



If desired even the reaction pressure upon the axis of rotation *c* may be compensated or balanced by a symmetrical arrangement of two sectors *s* and two carbon columns *k*. Fig. 2 illustrates apparatus in which the movement of the magnet armature *a* is rectilinear. The components of the pressures in the direction of the movement of the armature range from a positive maximum through zero in the horizontal position of the sectors shown in the figure, and then become negative. These components may be balanced wholly or partly by means of compression springs *g* according to the selected character of the magnetic pulling force in dependence on the air gap. (*Accepted October* 11, 1916.)

GAS ENGINES, PRODUCERS, HOLDERS, &c.

101,603. B. E. D. Kilburn, London (*Gebruder Sulzer Aktiengesellschaft, Winterthur, Switzerland*). **Internal Combustion Engines.** (4 *Figs.*) May 23, 1916. This invention relates to cylinders for single-acting combustion engines. *a* is the inner cylinder or liner, *b* is the casing, *c* the cover, and *l* the piston of the engine. The liner *a* is provided with ports *d* and *e* for the escape of the combustion gases and the admission of the scavenging and charging air respectively, as well as with an opening *f* with a sleeve *m* for accommodating the fuel valve *n* and the



starting valve *o*, which are arranged side by side. The outer cylindrical casing *b* forms, with the liner *a*, a cooling jacket. The cooling water is admitted at *h*, passes through the holes *u*, and escapes again at the top through the openings *i*. The inner cylinder or liner *a* is introduced from below into the casing *b*, its upper end bearing against an annular flange *k* on the underside of the cover *c*. The liner *a* and its cylindrical extension *m* are formed in one piece and together constitute a solid of revolution. (*Accepted October* 11, 1916.)

101,547. South Metropolitan Gas Company and D. Chandler, London. Gas-Fired Kilns. (3 *Figs.*) January 19, 1916.—Each kiln has two floors *d* and *e*, both perforated. The upper floor *d* is also double. The space above the floor *d* is heated by a row of burners *f* which send their flames in a vertical

Fig. 1.

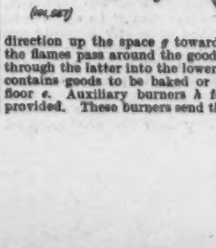
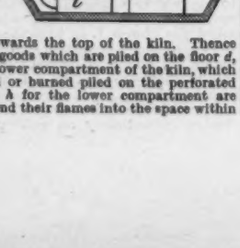


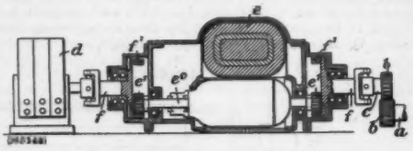
Fig. 2



direction up the space *g* towards the top of the kiln. Thence the flames pass around the goods which are piled on the floor *d*, through the latter into the lower compartment of the kiln, which contains goods to be baked or burned piled on the perforated floor *e*. Auxiliary burners *h* for the lower compartment are provided. These burners send their flames into the space within the double floor *d*, and thence the flames pass through the lower compartment to the outlet flue *i*. The flue *i* is connected by a pipe *j* to the central chimney *k* and also by the pipe *l* with the top of the next kiln of the series. The pipes *j* and *l* are furnished with valves by means of which the course of the combustion products from the kilns may be controlled. (*Accepted October* 11, 1916.)

MOTOR ROAD VEHICLES.

110,268. Société Anonyme des Etablissements L. Bleriot, Paris, France. Petrol Electric Drive. (1 *Fig.*) April 10, 1915.—The engine shaft *a* is arranged to drive by means of gears *b* a shaft *c*, coupled to which is the magneto *d*, so that the shaft *c* rotates at the same speed as the shaft *a* and consequently ensures the rotation at the same speed of the rotor of the magneto. For the purpose of driving the dynamo *e* at a higher speed, the shaft *c* is divided and the casing of the dynamo *e* is provided at each end with a bearing journalled in which is a short shaft *f* parallel to the shaft *c*0 of the armature. Interposed



between the shafts *f* and the adjacent extremity of the shaft *c*0 between the engine and the dynamo, is a speed-accelerating gear train constituted by an internal toothed rim *f*1 secured to the shaft *f* and a pinion *e*1 secured on the adjacent shaft end of the armature, and in a similar manner a speed-reducing gear *e*1, *f*1, is employed to couple the dynamo shaft *c*0 on the opposite side to the shaft of the magneto. These gears are so dimensioned that the two shafts *f* rotate at the same speed as the shaft *c*, while the armature shaft rotates at, for example, double the speed of the shaft *c*. (*Accepted October* 4, 1916.)

13,898/15. Brown Bayley's Steel Works, Limited, and T. H. Sanders, Sheffield. Laminated Springs. (4 *Figs.*) September 30, 1915.—This invention relates to shackles such as are used with laminated springs to prevent the spring plates becoming laterally displaced relatively to one another. According to this invention a shackle has a nib formed in the centre of the horizontal bar of the shackle, which nib engages in a slot at the end of one of the spring plates (preferably outside the stress area) which slot is either cut through the spring plate or cut partially through the spring plate. In the end of one of the

Fig. 1.

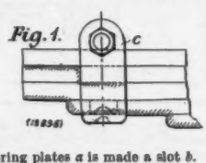
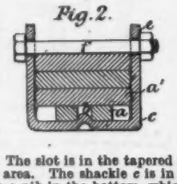


Fig. 2.



spring plates *a* is made a slot *b*. The slot is in the tapered end of the plate *a* outside the stress area. The shackle *c* is in the form of a U and is provided with a nib in the bottom, which is adapted to enter the slot *b* when the shackle is in position. In either side of the shackle are eyes *e* through which passes a bolt *f*, held in place by a nut. The eyes *e* are at such height in the sides of the shackle that the bolt *f* holds the plate *a* and the plates *a*1 above it firmly down on the bottom of the shackle, so that the nib *d* is held tight in the slot *b*. (*Accepted October* 11, 1916.)

101,590. F. J. Bretherton, P. W. Robson, and Clayton and Shuttleworth, Limited, Lincoln. Steering Mechanism. (3 *Figs.*) April 7, 1916.—In steering gear for motor vehicles of the type in which a fore-carriage is rotated about a vertical axis, the fore-carriage is provided with a rearwardly or forwardly projecting arm, the end of which is connected by radius rods to the axle at points as near as possible to the road wheels. *a* is the boiler on which is a seating *b* provided with a central opening to contain the upper steering pivot *c*. An arm *h* is provided upon the fore-carriage *d*. This arm is shown as projecting rear-

Fig. 1.

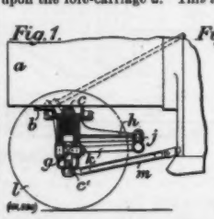
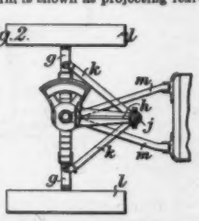


Fig. 2.



wardly. At the end of the arm *a* pivot *j* is provided to which the ends of radius rods *k* are connected, the other ends of the radius rods being attached to the axle *g* at points as near the road wheels *l* as possible. The rods *k* with the axle form a triangle, the apex of which is connected to the end of the arm *h*. The lower steering pivot *c*1 of the fore-carriage engages an eye joining a pair of radius rods *m*, the other ends of which are connected to the fire-box *n*. The two radius rods *k* impart the necessary turning effort to the axle *g* for steering purposes, and also form an improved means to take the thrust or pull to which the axle is subjected when the vehicle is travelling. (*Accepted October* 11, 1916.)

The Leading Coal Nation.—American records show that in 1810 the United States produced 20 tons of coal. In 1820 the total had risen to 3,080 tons; in 1830 to 285,739 tons; in 1840 to 6,266,233 tons; and in 1850 to 11,541,672 tons. In 1860 there had been a further advance to 14,721,439 tons; and in 1870 to 41,861,679 tons. Another ten years witnessed a still further rise to 63,822,830 tons; and in 1890 an aggregate of 141,866,931 tons was reached. The first year of the new century produced 240,789,310 tons, and this aggregate was carried in 1910 to 447,853,009 tons. The latest complete year of which statistics are available (1914) showed the vast output of 458,504,890 tons.